VOLUME XII

BULLETIN

of the

BUFFALO SOCIETY OF NATURAL SCIENCES

CATALOG OF THE FOSSIL FISHES IN THE MUSEUM OF THE BUFFALO SOCIETY OF NATURAL SCIENCES

BUFFALO, NEW YORK
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BY

L. HUSSAKOF, Ph.D.

AND

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CATALOG OF THE FOSSIL FISHES IN THE MUSEUM OF THE BUFFALO SOCIETY OF NATURAL SCIENCES

BY

L. Hussakof, Ph.D. and W. L. Bryant

INTRODUCTION

The Buffalo Society of Natural Sciences possesses a collection of fossil fishes numbering several hundred specimens. This collection includes materials from many different localities, but by far the larger part of it consists of specimens from the immediate vicinity of Buffalo. As regards these, it is the largest collection ever brought together, and as such is invaluable to students of the geology or the fish life of the Devonic of western New York and the neighboring region.

But notwithstanding the great interest of the collection, it has never been described, and only a few of the specimens have been studied by paleontologists. In this catalog, therefore, we propose to describe and illustrate this collection, and thus make it available for scientific purposes to all students of the vertebrates. We hope also that by directing attention to the rich fossil fields in the vicinity of Buffalo, this catalog may be the means of stimulating the interest of local collectors so that specimens may continue to accumulate and make possible some day the solution of a number of interesting

problems suggested by these primitive forms, which for the present must remain partly, if not wholly, unsolved.

A word in regard to the method of treatment adopted in this catalog. Our primary concern is with individual specimens rather than with species. Our aim is to describe and figure these specimens so that they may become scientifically available to all, and not merely to those having access to the collection. This, it seems to us, is after all the chief function of a catalog of this kind. Hence discussions of species, except in so far as the specimens in hand throw new light upon them, are not extensively gone into. And synonymies are omitted except in the few cases where it is necessary to indicate the reasons for a proposed change in nomenclature, or to epitomize the history of some little known, or lately proposed, name.

We wish here to express our grateful acknowledgments to Mr. Henry R. Howland of the Buffalo Museum, for his kindly interest in this work, and for the help and encouragement given us during the long period it has been in preparation. It has seemed to us especially fitting, as a permanent memorial of Mr. Howland's relations to this work, that his name be linked with one of the new forms represented in the Buffalo Museum; and we have accordingly proposed for one of the most interesting species from the vicinity of Buffalo, the name *Ptyctodus howlandi.*

SOURCES OF THE MATERIALS

The specimens in the collection are derived from several different sources, as follows:

1. A series of specimens from various horizons and localities, more especially from the Upper Devonic in the vicinity of Buffalo, which forms the nucleus of the collection. This part of the collection has grown up gradually in the course of the past three decades or longer, as a result of the geological and paleontological excursions in the vicinity of Buffalo by members of the society, as well as through the occasional gifts of specimens by various friends.

Of first importance in this connection are the collections made by Mr. F. K. Mixer of Buffalo, long a member of the society and at one time the curator of the museum. Mr. Mixer did pioneer work in investigating the Devonic fish-bearing formations in the vicinity of Buffalo, and to his zeal are due some of the most noteworthy speci-

mens in the collection, particularly those from the Rhinestreet shale at Sturgeon Point, on the shore of Lake Erie. Mr. Mixer has kept alive the knowledge of these localities, and has counseled all investigators—as both of the present writers well remember—seeking to collect in the region about Buffalo. It was he who guided Mr. Bryant to the locality at Sturgeon Point, and thus made possible the continuation of the work which he had himself so well begun.

Here also belongs a fine series of specimens from the Hamilton of Wisconsin, presented by Mr. Edgar E. Teller formerly of Milwaukee, now of Buffalo. Then there are a number of specimens which were presented by J. S. Newberry, most of them with labels in his own handwriting, and therefore especially valuable. There are some shark teeth from the phosphate beds of Florida, presented by Ottomar Reinecke; a number of fossil fish remains collected by John F. Carll on the second Pennsylvania survey, acquired by the Museum several years ago; and a few interesting specimens from Devonic horizons near Buffalo, collected and presented by Prof. Clifton J. Sarle.

2. A magnificent collection of fish remains from the rocks in the vicinity of Buffalo, brought together during the past four years by Mr. William L. Bryant. This collection more than trebled the entire fossil fish collection previously in the museum, and is the largest collection extant of specimens from the Devonic formations of New York State.

3. A series of fish remains collected by Mr. Bryant on a short trip to the Chemung of Pennsylvania, in 1913.

4. A small but valuable series of sharks and dinichthyids collected by Mr. Bryant from the Devonic shales near Cleveland, Ohio, in August, 1914.

5. A suite of specimens collected by Mr. Bryant from the Devonic rocks at Scaumenac Bay, Quebec, in 1915.

GEOLOGICAL FORMATIONS IN THE VICINITY OF BUFFALO

The city of Buffalo is very favorably situated with regard to formations containing fossil fishes. There are more than a dozen localities within fifty miles of Buffalo, over half of which may be reached by electric cars running out of the city. All are of Devonic age. A few hours' collecting at any one of these localities, is almost certain to yield some specimens.

The following table of geological formations will be useful in locating the relative position of the fossil fish horizons referred to in the catalog.

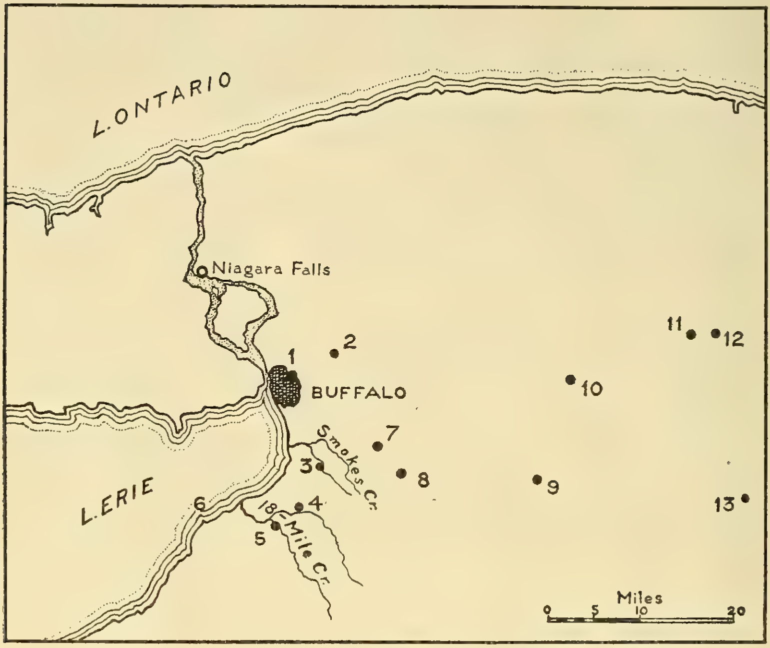

FIG. 1. FOSSIL FISH LOCALITIES WITHIN 50 MILES OF BUFFALO

1, Buffalo—northeastern city limits; *2*, Williamsville; *3*, Windom; *4*, Hamburg; *5*, North Evans; *6*, Sturgeon Point; *7*, Springbrook; *8*, Cazenovia Creek at East Aurora; *9*, Varysburg; 10, Alexander; *11*, Leroy; 12, Lime Rock; *13*, Mt. Morris.

MID DEVONIC FORMATIONS

Onondaga Limestone

At the northeastern limits of the city of Buffalo, and along the road to Leroy, there are a number of limestone quarries, some of them very extensively developed. These quarries are of Onondagan or Mid Devonic Age. An interesting series of fossil fish remains has been obtained from them, among which the following species can be identified. The most remarkable form among them is that represented by the curious dental plates, ornamented on the outer face

*The Devonic System in New York State with Special Reference to the Formations in the Vicinity of Buffalo**

	GROUPS	STAGES	FORMATIONS NEAR BUFFALO
Upper Devonic	Chautauquan	Chemung [Catskill = local facies]	
	Senecan	Portage	Wiscoy shale Laona sandstone Gardeau shale Dunkirk shale Hanover shale Angola shale Rhinestreet shale Cashaqua shale Middlesex shale
		Genesee	West River shale Genundewa limestone (*Styliola*) Conodont bed Genesee shale
		Tully	Pyrite layer
Mid Devonic	Erian	Hamilton	Moscow shale Tichenor limestone Ludlowville shale Skaneateles shale
		Marcellus	Cardiff shale Stafford limestone Marcellus shale
	Ulsterian	Onondaga Schoharie grit	Onondaga limestone
Lower Devonic	Oriskanian	Esopus grit Oriskany beds	
	Helderbergian	Port Ewen limestone Becraft limestone New Scotland beds Coeymans limestone	

*The classification into groups and stages is that of Clarke and Schuchert ("The nomenclature of the New York series of geological formations:" *Science*, n.s., x, 874–878, 1899), with some modifications introduced later by Director J. M. Clarke in the bulletins and memoirs of the New York State Museum.

The formation names are those used in a recent paper on the geology of Erie County by Frederick Houghton (*Bull. Buffalo Soc. Nat. Sci.*, xi, 1–92, 1914).

with closely crowded tubercles, described on a subsequent page of this catalog as a new genus of ptyctodont, under the name of *Deinodus.*

Macropetalichthys rapheidolabis Norwood & Owen
Acanthaspis armata Newberry
Eczematolepis fragilis (Newberry)
Arthrodire indet. [fragmentary plates]
Machœracanthus major Newberry
Deinodus bennetti, n. gen., n. sp.
Onychodus sigmoides Newberry

This is a typical Onondagan fauna, with all the more important species known from other Onondagan formations, for instance, the Delaware limestones of Ohio. It should be remembered, however, that the Onondaga of New York is not exactly coeval with the Delaware limestones of Ohio; and that, therefore, the faunas cannot be expected entirely to correspond. This accounts for the presence in the Buffalo Onondaga of such a form as *Deinodus*, and its absence from the Ohio formations; or the absence from the New York horizon of some forms present in the former.

Marcellus and Hamilton

The Erian Group, including the Marcellus and Hamilton stages, is well represented in the vicinity of Buffalo, although not so extensively developed as at some other localities in New York State. Fossil fishes are extremely rare in these formations. In the vicinity of Buffalo only a single species has been obtained from them in many years of collecting by various investigators. This species is *Machœracanthus longœvus* Eastman, the type of which is from the "Trilobite bed" (lower portion of the Hamilton), near the mouth of Eighteen Mile Creek.

UPPER DEVONIC FORMATIONS

The other fish bearing formations near Buffalo are of Upper Devonic Age—Tully, Genesee and Portage. The most fruitful localities are: (1) along the shore of Lake Erie, near Sturgeon Point, about 15 miles west of Buffalo (fig. 1); and (2) on Eighteen Mile Creek, near the villages of North Evans and Hamburg, N. Y. From these two localities the bulk of the Buffalo collection has been derived.

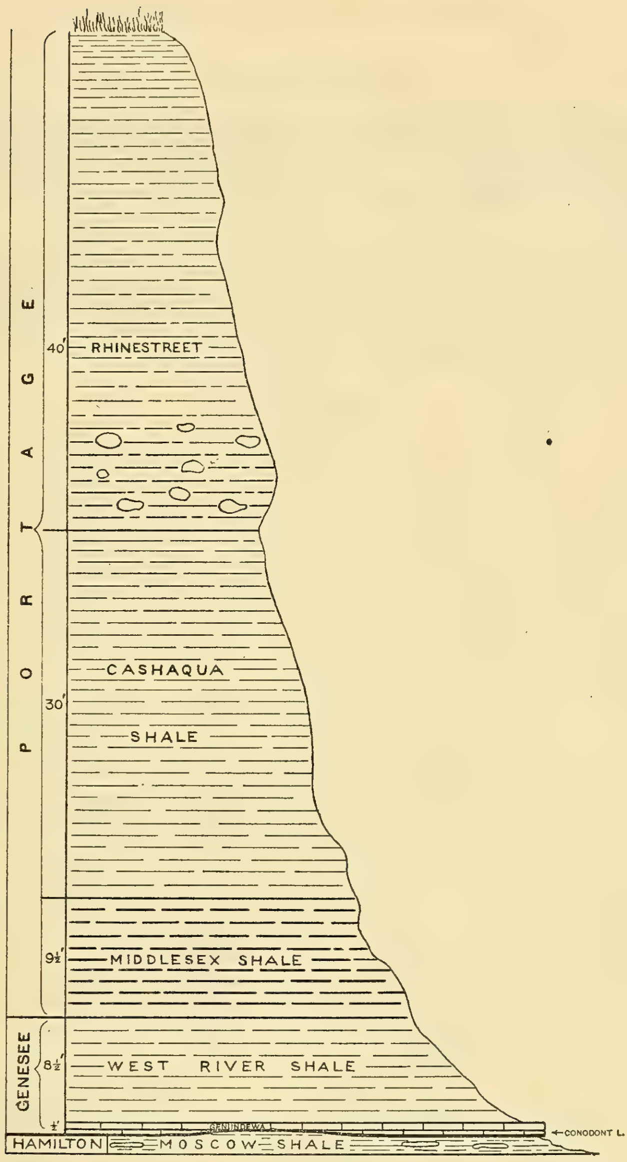

FIG. 2. SECTION ON EIGHTEEN MILE CREEK, SHOWING EXPOSURE OF THE UPPER DEVONIC FORMATIONS

The thicknesses are those given by A. W. Grabau in his paper, "The faunas of the Hamilton Group of Eighteen Mile Creek and vicinity." (*16th Ann. Rept. State Geologist, N. Y.*, 231–339, 1899; especially p. 240.) The formation names are the ones used by F. Houghton in his paper "The geology of Erie County." (*Bull. Buffalo Soc. Nat. Sci.*, xi, 1–92, 1914.)

Tully Pyrite Layer

The Tully limestone is absent in Erie County, but on Cazenovia Creek, near Springbrook, a bed of solid pyrite, 4 or 5 inches thick and underlying the black Genesee shale, apparently marks the Tully horizon.

Dental plates of two species of fishes occur in this bed, both belonging to the Ptyctodontidae: *Ptyctodus compressus* Eastman and *Palaeomylus*, sp. Besides these there are undetermined Pleuracanthid shark teeth, perhaps belonging to the genus *Dittodus*.

Conodont Bed[1]

(Pls. 2 and 3)

So many of the specimens described in this catalog are from the Conodont bed, that this formation needs to be discussed in some detail. The Conodont bed is a layer of limestone about four inches in maximum thickness, constituting the base of the Genesee in certain sections on Eighteen Mile Creek. It lies immediately below the Genundewa (*Styliola*) limestone, and is best exposed in a few sections near the railroad bridge at the village of North Evans in Erie County. In typical exposures, it thins out in both directions and may, therefore, be regarded as occurring in lenticular patches. The name "Conodont bed" was proposed as long ago as 1879, by G. J. Hinde, the designation having been suggested by the abundance of Conodonts in some parts of the formation.[2]

Lithologically, the Conodont bed is an impure limestone containing large numbers of quartz grains, small pebbles, crinoid stems, fragments of fossil wood, and other matter. Here and there are fragments of pyrite and more or less broken remains of fishes and invertebrates. The fishes were first recorded by Hinde, who wrote concerning them as follows:

"In addition to the Conodonts, there are in this same bed numerous fragments of Crinoid stems, *bones and plates of undetermined fishes, and teeth closely resembling, if not identical with, those of Ptyctodus.*"[3]

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[1] A preliminary account of the Conodont bed fauna was presented by the authors before the Paleontological Society, at the Philadelphia meeting, December, 1914. Abstract in *Bull. Geol. Soc. Amer.*, vol. 26, p. 154.

[2] "One particular band of the limestone (near the village of North Evans), which I purpose to designate the Conodont-bed, is filled with fragments of these small teeth." (*Quart. Journ. Geol. Soc.*, London, xxxv, 352, 1879.)

[3] Ibid., p. 353. Italics are ours.

But although fish remains were known to occur in this formation so long ago, they were practically not represented in collections until they were rediscovered a few years ago by Mr. Bryant. Since then he has visited the locality at frequent intervals and has made a considerable collection of specimens, and on one occasion both authors of this catalog visited the locality together for the purpose of collecting.

The mode of occurrence of the fossils, in places where they are abundant, is well illustrated in figure 3. This represents a slab of limestone 11 by 18 inches, which contains 21 specimens of fossils and fragmental material. The remains are, however, not equally abundant throughout the bed. They seem to have become piled up in some places, while at others they are almost absent. Here and there one may encounter an almost complete fish plate.

The following is a list of the species at present known from the Conodont bed:

Arthrodira

Coccosteus sp.
Dinichthys magnificus, n. sp.
Dinichthys newberryi Clarke
Dinichthys pustulosus Eastman
Dinichthys insolitus, n. sp.
Dinichthys sp. [numerous isolated plates]
Stenognathus denticulatus, n. sp.
Stenognathus insignis, n. sp.
Perissognathus aduncus, n. gen., n. sp.
Machœrognathus woodwardi, n. gen., n. sp.
Copanognathus crassus, n. gen., n. sp.
Dinomylostoma buffaloensis, n. sp.
Dinomylostoma sp. [juvenile]
Aspidichthys notabilis Whiteaves
Acanthaspis, sp.

Incertœ Sedis

Holonema abbreviatum (Eastman)
Oëstophorus lilleyi ? (Newberry)
Eczematolepis fragilis (Newberry)
Arthrodires indet. [fragmentary plates]
Acmoniodus clarkei, n. gen., n. sp.

FIG. 3. A SLAB OF CONODONT LIMESTONE, 11 BY 18 INCHES, SHOWING THE ABUNDANCE OF FOSSIL REMAINS IN CERTAIN SPOTS IN THIS BED. TWENTY-ONE SPECIMENS ARE INCLUDED IN THIS SLAB.

a, Dinichthys insolitus; *b*, Ptyctodus compressus; *c*, Arthrodire plate; *d*, Orthoceras sp.; *e*, Symphyseal spine of Ptyctodont; *f*, Water-worn pebble; *g*, Ctenacanthus wrighti; *h*, Fragment of a mandible; *i*, Stethacanthus præcursor; *j*, Machæracanthus sp.; *k*, Imperfect tooth of Dittodus priscus; *l*, Beak of Ptyctodus howlandi; *m*, Tritor of Ptyctodus compressus; *n*, Water-worn pebble; *o*, Tritor of Ptyctodus howlandi; *p*, Suborbital of Dinichthys sp; *q*, Tritor of Ptyctodus compressus; *r*, Fragment of Ctenacanthus wrighti; *s*, External occipital of Dinichthys sp.; *t*, Dittodus priscus; *u*, Ptyctodus howlandi.

Ptyctodontidæ

Ptyctodus calceolus Newberry & Worthen
Ptyctodus compressus Eastman
Ptyctodus howlandi, n. sp.
Ptyctodonts indet. [plates and tritors]
Rhynchodus telleri, n. sp.
Rhynchodus ornatus, n. sp.
Palæomylus lunaformis, n. sp.
Palæomylus sp.
Dermal plates [gen. and sp. indet.]

Elasmobranchii

Cladodus urbs-ludovici Eastman
Acanthodia indet. [fin-spines]
Dittodus priscus (Eastman)
Dittodus striatus (Eastman)
Dittodus grabaui, n. sp.
Synthetodus calvini Eastman
Orodus devonicus, n. sp.

Ichthyodorulites

Anodontacanthus pusillus, n. sp.
Ctenacanthus wrighti Newberry
Ctenacanthus sp.
Gyracanthus sp.
Machæracanthus peracutus Newberry
Stethacanthus præcursor, n. sp.

Dipneusti

Dipterus gemmatus, n. sp.
Dipterus sp.

Crossopterygii

Onychodus sigmoides Newberry

Actinopterygii

Ganoid tooth [indet.]

Several interesting conclusions may be drawn from this list as well as from considerations of the character of the Conodont layer itself.

1. In the first place, we have here one of the most remarkable assemblages of fossil fishes known from any Devonic formation. It includes no less than 27 genera (not counting two or three[4] too fragmentary for identification) with about 40 species. It is therefore nearly as rich in species as the fauna of the Cleveland shale of Ohio, although the specimens are, of course, not to be compared with the latter in point of preservation. The fauna will also stand comparison in richness with any of the local facies of the Old Red Sandstone of Scotland, such as the Achanarras, the Orkney, or the Cromarty faunas; or with the remarkable fish fauna made known ten years ago by Jaekel, from the Upper Devonic at Wildungen, Germany.[5]

Apart from the large number of genera and species represented, the Conodont-bed fauna is remarkable for the presence of so many different groups. Nearly every division of fishes that existed in Upper Devonic times is represented—Sharks (all four divisions: Pleuropterygii, Ichthyotomi, Acanthodia and Euselachia); Arthrodira, Ptyctodontidæ, Ichthyodorulites, Dipneusti, Crossopterygii and Acanthopterygii.

2. Another remarkable feature about the Conodont fauna, is the large number of forms peculiar to it. Out of a total of 34 identifiable species, 15 are known only from this formation; the remaining 19 are represented by groups of fours, fives, or less, in several different formations. The latter species are mostly such as had a long geological history, some of them ranging through several successive formations, or had a very wide geographical distribution.

The following table shows the range of the fossil fishes common to the Conodont bed and other formations. As will be seen from this, 4 species are common to the Conodont bed and the New Albany shale. This is not surprising when we consider that both formations are of Genesee age. It may also be noted that the mode of preservation of the fossils and the character of the matrix of the New Albany shale is, in certain areas at least, similar to those of the Conodont bed. But it is surprising to find 6 species surviving from the Hamilton.

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[4] For instance, the Acanthodian represented by a fin-spine, and the extraordinary plates ornamented with broad parallel ridges, illustrated in figure 37, page 106.

[5] O. Jaekel: Neue Wirbeltierfunde aus dem Devon von Wildungen. *Sitzunsb. Gesell. Naturf. Freunde*, Berlin, 1906, 73–85, with 10 figures.

Geological Range of Conodont Bed Fishes Known to Occur in Other Formations

CONODONT-BED SPECIES	MID DEVONIC				UPPER DEVONIC					
	New York		Ohio	Wisconsin	New York		Ohio	Indiana—Kentucky	Iowa	Manitoba
	Onondaga	Hamilton	Columbus and Delaware limestones	Hamilton	Genundewa	Portage	Cleveland shale	New Albany	State Quarry	Upper Devonic
Dinichthys magnificus	...	...	...	...	...	×	...	...	...	...
Dinichthys newberryi	...	...	...	...	×	?	...	?	...	...
Dinichthys pustulosus	...	...	...	×	...	...	...	×	×	...
Stenognathus gouldi(?)	...	...	...	...	...	...	×	...	...	...
Aspidichthys notabilis	...	...	...	...	...	...	...	...	...	×
Holonema abbreviatum	...	...	...	...	...	×	...	×	...	...
Oëstophorus lilleyi	...	...	...	×	...	...	...	...	...	...
Acanthaspis (?) armata	×	...	×	×	...	...	...	...	...	...
Eczematolepis fragilis	×	...	×	×	...	...	...	...	...	...
Ptyctodus calceolus	...	...	...	×	...	×	...	×	×	?
Ptyctodus compressus	...	...	...	...	...	...	...	...	×	...
Cladodus urbs-ludovici	...	...	...	...	...	...	...	×	...	...
Dittodus priscus*										
Dittodus striatus*										
Synthetodus calvini	...	...	...	...	...	...	...	...	×	...
Ctenacanthus wrighti	...	×	...	...	...	...	...	...	...	...
Machæracanthus peracutus	×	...	×	...	...	...	...	...	...	...
Machæracanthus longævus	...	×	...	...	...	...	...	...	...	...
Onychodus sigmoides	×	?	×	×	...	...	...	...	...	...

* Known hitherto only from a peculiar formation, of Upper Devonic age, at Elmhurst, Ill.

3. While the Conodont fauna is clearly of marine origin, as shown by the character of the rock, which is a limestone, and by the abundance of Conodonts, now generally regarded as the teeth of annelids, and hence belonging to the sea or the seashore, it is noteworthy that there are some forms, e. g., dipnoan dental plates, which are generally regarded as indicative of fresh-water. How can we explain this seeming disparity? The answer may be found in the peculiar character of the formation. From the broken and abraded condition of most of the remains, and from the presence of pebbles and other fragmental matter, we may conclude that this band of limestone was laid down close to shore, and that many of the remains were rolled and tossed before they finally came to rest on the bottom. On the authority of Dr. G. R. Wieland we may state that fragments of fossil wood have been found in the Conodont bed, which by their worn and abraded surfaces show unmistakably that they had been tossed about before they had settled to the bottom.

All the evidence points to the fact that the Conodont bed was deposited close to shore. On such a view we can readily explain the great abundance of Conodont teeth in the formation: we may conceive that the annelids they represent lived in shallow water, or, indeed, on the beach itself, and thus would be washed into the deposit near shore. It seems probable, also, that some of the remains, for instance the dipnoan dental plates, were carried down by a river which emptied close to the location of the Conodont bed sediments. It appears not unlikely that the Conodont bed was a sand-bar, or a series of sandbars, at times exposed to the air, and situated in close proximity to the mouth of a river. Such conditions would account for all the peculiar circumstances connected with this formation—(1) its occurrence in lenticular patches; (2) the broken and abraded condition of the fossils, as well as the admixture of pebbles and fragmental matter; (3) the abundance of Conodont teeth; (4) the presence of fragments of fossil wood; (5) the commingling of fresh-water with marine forms; and lastly (6) account for the great diversity of forms present.

Genundewa and West River (Genesee)

In the Genundewa (or *Styliola* layer), fossil fishes are rather rare despite the fact that the layer rests directly on the Conodont bed (where this is present), in which fossils are so abundant. There are only a few remains from this formation in the Buffalo museum. Among them is a small slab containing associated ventral plates of a small dinichthyid, perhaps *Selenosteus*; and a plate which seems referable to *Acanthaspis armata*.

From the West River shale, which overlies the Genundewa, only two specimens have thus far been collected—a plate of *Holonema abbreviata* (Eastman), and the impression of a mandible of *Dinomylostoma buffaloensis*. They came from a band of limestone a few feet above the Genundewa.

In addition to the above mentioned specimens, a *Gyracanthus* spine, representing a new species, was collected from a Genesee horizon near Canandaigua Lake, by Prof. Clifton J. Sarle, which is described on a subsequent page of this catalog.

Rhinestreet (Portage)

The Rhinestreet, or "Black Naples," shale is well developed in the vicinity of Buffalo, having a total thickness in Erie County of

185 feet. The best fossiliferous exposures are at Sturgeon Point on the shore of Lake Erie, and along Eighteen Mile Creek. A considerable suite of fossil fishes has been collected from this formation and is preserved in the Buffalo Museum. They were collected by Mr. F. K. Mixer, and, during the past few years, by Mr. Bryant.

The following is a list of the Rhinestreet species represented in the Buffalo Museum:

Euostracophori

Phyllolepis elegans, n. sp.

Arthrodira

Coccosteus parvulus, n. sp.
Coccosteus sp.
Dinichthys intermedius (?) [mandibles]
Dinichthys magnificus, n. sp.
Dinichthys tenuidens, n. sp.
Dinichthys sp. [ventral armor; indet. isolated plates]
Stenognathus dolichocephalus (Eastman)
Stenognathus ringuebergi (Newberry)
Stenognathus mixeri, n. sp.
Selenosteus sp.
Dinomylostoma sp. [juvenile]
Acanthaspis sp.

Incertæ Sedis

Arthrodire indet. [juvenile plates]

Elasmobranchii

Cladoselache eastmani Dean
Dittodus sp.

Ichthyodorulites

Atopacanthus dentatus, n. gen., n. sp.

Acanthopterygii

Rhadinichthys devonicus (Clarke)
Rhadinichthys antiquus (Williams)
Palæoniscid indet.

LIST OF NEW GENERA AND SPECIES DESCRIBED IN THIS CATALOG

New Genera

New Species

SYSTEMATIC DESCRIPTION OF THE COLLECTION

EUOSTRACOPHORI[5a]

Genus **Phyllolepis** Agassiz

Until very recently this genus was known only by detached plates, and was one of the puzzles of paleichthyology. But the discovery of a nearly complete specimen showing the plates in natural association, has solved this puzzle. This remarkable specimen was in a collection obtained from an Old Red Sandstone quarry, at Dura Den, Scotland, which had been closed for several decades, but was reopened a few years ago by a committee of the British Association, for the purpose of obtaining a collection of the fossil fishes known to occur in it.

A preliminary account of the *Phyllolepis* specimen, with a figure, was published by A. S. Woodward in 1915 (Rept. Brit. Assoc. Adv. Sci., 84th Meeting, p. 122, pl. ii). His conclusion as to its affinities is as follows:

> The whole fossil is most suggestive of the ventral aspect of the curious Devonian Ostracoderms *Drepanaspis* and *Psammosteus*. It agrees with *Drepanaspis* in showing two principal median plates one behind the other, though in *Phyllolepis* they are more nearly equal in size. It corresponds with *Psammosteus* in exhibiting a prominent pair of lateral cornua at the hinder end of the series of small marginal plates, opposite the middle of the posterior median plate. It differs from both in lacking separate small tessellated plates. There is, therefore, not much doubt that *Phyllolepis* is a genus of Ostracoderms most nearly allied to the Drepanaspidæ or Psammosteidæ.

Phyllolepis elegans, n. sp.

(Pl. 32, fig. 2)

E 2438 *Type.*—An elliptical plate 5 by 11.5 cm.

Formation and Locality.—Rhinestreet shale (Portage); Forks of Cazenovia Creek, near E. Aurora, N. Y. Collected by W. L. Bryant.

Elliptical plates ornamented with parallel lines arranged concentrically around a point somewhat nearer one extremity of the plate than the other. Lines near the periphery a millimeter or more in width, becoming progressively finer toward the centre. Central por-

[5a] The term *Euostracophori*, to include the Ostracoderms as commonly understood, minus the Antiarchi, was introduced by Hussakof in 1906. *Mem. Amer. Mus. Nat. Hist.*, ix, 135.

tion of the markings resembling a fingerprint, except that the lines are all discrete and do not join. In this central portion of the ornamentation, the lines parallel to the long axis of the plates are somewhat recurved inward toward the centre of the plate.

Remarks.—This species is represented by specimens of various sizes, of which the type is the largest that has come under notice. It is the second species to be described from America, the other being *P. delicatula* Newberry (*Paleozoic Fishes North Amer.*, p.97, pl. xix, fig. 11), from the Chemung of Pennsylvania, from which it differs especially in ornamentation.

The following specimens are all from the Rhinestreet shale (Portage), at Sturgeon Point, on Lake Erie. They were collected by Mr. F. K. Mixer.

E 2039 Small elliptical plate 60 by 25 mm.; finely striated, the striations following the contour of the edge.

E 2040 Striated elliptical plate, 95 by 30 mm. (broken).

E 2041 Small plate with fine striations running parallel to the margin, 55 by 35 mm.

PLACODERMATA

In this catalog we adopt the view that the Antiarchi, the highest division of the old group Ostracophori, and the Arthrodira, are related. It seems impossible that such a remarkable correspondence between the two groups in the arrangement of the armor of the head and front portion of the body; in the head in both being movable on the shoulder armor; in the agreement of the fundamental plan of the dorsal armor plates; and the correspondence down to details in the plan of the ventral armor, can be due to parallelism and not to relationship.[6]

In this work we adopt the following arrangement of these primitive forms:

Placodermata (McCoy, 1848).[7]

1. Antiarchi (*Bothriolepis*, *Pterichthys*, etc.).
2. Macropetalichthyida.
3. Arthrodira (*Coccosteus*, *Dinichthys*, etc.).

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[6] For a discussion of this subject see L. Hussakof: Studies on the Arthrodira. *Mem. Am. Mus. Nat. Hist.*, ix, 105–154, 1906, pls. xii, xiii; especially pp. 128–135.

[7] *Ann. and Mag. Nat. Hist.*, 2 ser., ii, 1–10, 1848.

I. Antiarchi

Genus **Bothriolepis** Eichwald

This is the best known genus among the Antiarchi, exquisitely preserved specimens showing the entire creature—with the unarmored part of the body, tail and two dorsal fins—having been found. These specimens come from the fine-grained Upper Devonic sandstone exposed on the north shore of Scaumenac Bay, Quebec, and were discovered and first made known by Prof. William Patten.[8]

In addition to *Bothriolepis canadensis*, there are three other species of the genus in North America—*B. nitida* and *B. minor*, from the Chemung and Catskill of New York and Pennsylvania; and *B. coloradensis* from the Upper Devonic of Colorado.

In the Buffalo Museum there are a large number of specimens of *Bothriolepis* representing two species.

Bothriolepis canadensis (Whiteaves)

E 2576 Specimen little crushed but lacking head, showing the greatest depth of the animal to have been about half its greatest width. The trunk of *Bothriolepis* was, therefore, deeper than indicated by current restorations.

Upper Devonic: Scaumenac Bay, Quebec. This and the following specimens collected by W. L. Bryant, 1915.

E 2352 Complete head and trunk, dorsal view.

E 2353 Head and trunk of large individual in dorsal view, showing sensory canals and well-preserved lateral appendages.

E 2354 Head and trunk of very large specimen, in dorsal view.

E 2355 Head and trunk, in dorsal view.

E 2356 Very young individual, in counterpart, showing complete head and trunk 12 mm. in length.

E 2357 Impression of visceral surface of anterior half of ventral armor.

E 2358 Anterior dorsomedian plate, in visceral view, showing median keel.

[8] New facts concerning Bothriolepis. *Biol. Bull.*, vii, 1904. The evolution of the vertebrates and their kin. Philadelphia, 1912; *passim*.

E 2359 Antero-dorsomedian plate, in visceral view.

E 2360 Proximal portion of right arm showing articular process.

E 2361 Dorsal aspect of nearly complete individual.

E 2362 Average-sized specimen, in dorsal aspect.

E 2363 Complete head, trunk and appendages of immature specimen.

E 2364 Antero-dorsomedian plate.

E 2365 Postero-ventrolateral plate, in counterpart, from a concretion in sandstone.

E 2366 Median occipital plate from a concretion in sandstone.

E 2367 Posterior half of the plastron.

E 2368 Complete head and trunk.

E 2369 Complete head and trunk.

E 2577 Nearly complete individual, in dorsal view.

E 2578 Very young individual, in dorsal view.

E 2579 Very young individual, in dorsal view.

E 2580 Head and anterior half of trunk, showing dorsal and ventral aspects.

E 2581 Head and trunk, in dorsal view.

E 2582 Ventral armor, in visceral view.

E 2583 Head and trunk, in dorsal view.

E 2584 Nearly complete specimen, in ventral view.

E 2585 Head and trunk, in dorsal view.

E 2586 Large individual, in dorsal view.

E 2587 Large specimen, in ventral view.

E 2588 Head and trunk, in dorsal view.

E 2589 Head and trunk of very large specimen, in dorsal view.

E 2590 Dorsal aspect of small individual.

Bothriolepis nitida Leidy

E 2502 Articular plate of pectoral appendage. On the same piece of rock is a scale of *Holoptychius giganteus*? Ag.
Catskill; Seeley Creek, branch of Lambs Creek, Mansfield, Tioga County, Pa. Collected by W. L. Bryant, 1913.

E 2504 Fine impression of ventromedian plate, in external view. Other data same as preceding.

E 2501 Impression of imperfect right anterior ventrolateral plate. Catskill; Troy, Bradford County, Pa. Carll Coll.

E 2503 Cast of postero-dorsolateral, showing the sensory canal. Original in Philadelphia Academy of Sciences. Catskill; Bradford County, Pa. Sherwood Coll.

II. Macropetalichthyida

Macropetalichthys rapheidolabis Norwood and Owen

The genus *Macropetalichthys* is known only by head shields; and the structure of these is not yet entirely understood. Three species are recognized, two from Europe and one from America. The last, *M. rapheidolabis*, is the best known one of the three, being represented by more or less well-preserved cranial shields in various collections, the best of them from the Delaware limestone (Onondaga) of Ohio. The crania have not been found associated with other remains in such a way as to make it certain that they belong together; and although a number of new specimens have been obtained in recent years, nothing of importance can be added to what is already known regarding this form. The structure of the head shield was discussed by Eastman in 1897;[9] and the interesting history of the discovery and study of this genus was given by the same author in 1908.[10]

In the Buffalo museum there are several specimens, but none of them throws any additional light on the structure of this form.

E 1865 Fragment of a cranium ornamented with stellate tubercles. Onondaga limestone; Cement Quarry, Buffalo, N. Y. Collected by W. L. Bryant.

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[9] Eastman, C. R. On the characters of *Macropetalichthys*. *Am. Naturalist*, xxxi, 493–499, 1897.
[10] *Mem. N. Y. Acad. Sciences*, x, 100, 1908.

E 1866 Fragment of a cranium with stellate tubercles and showing a sensory canal.

Other data same as preceding.

E 1870 Uncrushed cranium, in inner view. This specimen shows considerable arching of the cranium; greatest width (across marginals) 16.5 cm., greatest depth 5 cm. The head of Macropetalichthys was, therefore, nearly one-third as deep as wide.

Onondaga limestone; Leroy, N. Y. Collected by F. Mixer.

E 1871 Large cranium, in top view, denuded of ornamentation; in counterpart.

Onondaga limestone; Marblehead, Ottawa County, Ohio.

III. Arthrodira

Coccosteus decipiens Agassiz

E 2372 Portions of two individuals showing various head and body plates, the so-called pelvic basipterygia, and the dorsal fin-supports.

Middle Old Red Sandstone; Sandwick, near Stromness, Orkneys.

Coccosteus canadensis Woodward

(Pl. 5, figs. 1–3)

This is the best known of the five or six American species of *Coccosteus*, an almost complete specimen having been described within the past few years by Hussakof.[11] The species is rather rare only one or two plates usually being found in the course of several weeks collecting at the type locality. It is a great satisfaction to the authors to be able to describe a noteworthy specimen, collected by Mr. Bryant in August, 1915. This specimen displays the upper dentition, which is shown for the first time so clearly in a specimen of *Coccosteus*.

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[11] Notes on Devonic fishes from Scaumenac Bay, Quebec. *N. Y. State Mus., Bull.* No. 158, 127–139, pls. 1–3 and 6 figs., 1912.

E 2374 The specimen is contained in a piece of shale, 15 by 21 cm., which had broken out of its place and was picked up at the foot of the bank. It must have been weathered out by ice or frost. The specimen represents a large individual, larger than the one figured by Hussakof, and displays the following plates:

Left Suborbital (*SO*).—This plate is shown in inner view. The anterior process is well developed; its superior surface is broad and excavated for lodging the eye. The whole plate closely resembles that of *Dinichthys*. The upper margin is somewhat broken, but judging from one point at which the entire width of the element is preserved, it would seem that the blade (or plate minus the process), was deeper, i.e., broader, than in other species of *Coccosteus*.

Length, including process, 81 mm.; max. depth (measured at hinder fourth of plate), about 40.

Left Mandible (*Mnd*).—This is represented by the impression of the outer face of a mandible lacking the front half of the functional portion and the posterior extremity of the blade portion. The depth of the blade at its middle is 25 mm. The mandible was therefore of considerable size for a *Coccosteus*; but this is in keeping with the large size of the specimen as a whole. The functional margin of the mandible was a continuous bevelled edge, with denticles (three in number) only at the posterior extremity where it descends to join the blade portion. It was thus strikingly like that of *Dinichthys*. To anticipate the criticism that the specimen is in fact a *Dinichthys* and not a *Coccosteus*, we may say that we have observed a similar condition in *Coccosteus* mandibles belonging to old individuals; one in the British Museum, which is free of all matrix, and which unquestionably is *Coccosteus* coming from the Old Red Sandstone, also shows a bevelled, non-denticled cutting margin; the "teeth" apparently wore off with age, persisting only at the posterior angle where they are not so much exposed to wear.

Left Antero-superognathal (*ASG*).—This element is shown in inner view, and exhibits the area against which the mandibular beak closed. This area is striated by

lines of wear. The form of the element is well shown in Plate 5, figure 3. It will be seen that it is rather broad, and that its parts are less differentiated than in *Dinichthys*; hence that it is more primitive than the element in the latter genus. The process for attachment is, however, well developed.

Measurements	*mm.*
Height (including process and allowing 1 mm. for the missing tip)	25
Greatest width	18
Height of worn area	9
Width of process	7

Left Postero-superognathal (*PSG*).—This, like the preceding element, is shown in inner view (Pl. 5, fig. 2). It resembles the same element in *Dinichthys*. The functional margin shows prettily the lines of wear produced in grinding against the mandibular cutting edge. These lines, it may be mentioned, are, both in this element and in the antero-superognathal, all vertical and parallel to one another, thus proving that the movement of the upper "teeth" against the lower was vertical, with little or no lateral motion. It is noteworthy that the cutting margin is not uniform in width throughout, but that the anterior half is nearly twice as high as the hinder half, there being an abrupt change from the one to the other. (Pl. 5, fig. 2). But whether this feature was pathologic in this specimen, or a constant feature of the species cannot be said. At the posterior end of the cutting margin are two well-developed denticles.

Measurements	*mm.*
Length, antero-posteriorly	27
Total height (end of process lacking)	22
Maximum height, exclusive of process	19
Height of wearing margin in anterior half of "tooth"	5
Height of wearing margin in posterior half of "tooth"	3

Left Antero-ventrolateral (*AVL*).—This plate is incomplete, only the anterior two-thirds being preserved; it is shown in outer view. As far as preserved it agrees in form with that of the almost complete *Coccosteus* in the

New York State Museum referred to above. It shows the ornamental tubercles well. They are pointed, and stellate at their bases; in the center of the plate they are crowded and very small, while near the periphery they are much larger, fewer, and more widely spaced. A lateral line is present on this plate, as in some other examples of this element in various species of *Coccosteus*. It begins near the inner side at about one-third the length of the element from the front margin, extends inward as a straight shallow groove to about the middle of the plate, then turns upward in a curve; this latter portion being indicated in this specimen only by a double arrangement of the ornamentel tubercles and not by a groove.

Length, as far as preserved, 75 mm.

Width, at level of horizontal arm of lateral line, 61.

Lateral (*L*).—Only the lower limb of one lateral plate is preserved. It is shown in inner view.

There are also the extremities of two other plates preserved, near the edge of the specimen; shown in inner view.

Upper Devonic; Scaumenac Bay, near village of Migouasha, Quebec, Canada. Collected by W. L. Bryant, August, 1915.

Coccosteus parvulus, n. sp.

(Pl. 4, figs. 1–3. Pl. 70, fig. 1)

E 2371 *Cotypes.*—(1) Impression in shale of three cranial plates—a median occipital, shown in inner view, and, on either side of it, a plate shown in outer view (Pl. 4, figs. 1, 3).

E 2372 (2) Impression of outer face of a postero-ventromedian (Pl. 4, fig. 2).

Formation and Locality.—Rhinestreet shale (Portage); Lower fork of Eighteen Mile Creek, near Hamburg, Erie County, N. Y. Collected by W. L. Bryant.

A species of about the size of *Coccosteus decipiens*, with plates ornamented with small, closely-crowded, stellate tubercles. Distinguished from other species by the form of the plates mentioned above. Postero-ventromedian lozenge-shaped, with broad lateral flanges for overlap by the other ventral plates; length, 15 mm., width, 11. Some of the tubercles of this plate, as seen in a wax squeeze, are clearly stellate. Median occipital distinguished from that of other species by the fact that its lateral margins do not converge rapidly anteriorly; i.e., the plate, exclusive of the postero-lateral cornua, is more nearly rectangular than in other species, for example in *C. decipiens*, in which it is triangular with the apex of the triangle cut off.

Remarks.—This is one of the smallest American species of *Coccosteus* known. It recalls *C. macromus* Cope, from the Chemung, but this species was based on one or two plates almost too fragmentary for identification as *Coccosteus*.

The following specimen apparently also belongs to this species.

E 2597 Impression of a cranial shield, of which nearly the entire outline can be made out (Pl. 70, fig. 1). A few of the sensory canals are also discernible. From the strong posterior excavation of the median occipital, which resembles that of the cotype (Pl. 4, fig. 3); from its size, and geological horizon, it apparently belongs to this species. The head is rather more elongated antero-posteriorly than is usual in *Coccosteus*.

Measurements	*mm.*
Total length	82
Length, tip of rostrum to middle of posterior margin of med. occipital	70
Width at middle of orbits	40
Greatest width, posteriorly	80

Coccosteus, sp.

In addition to the preceding specimens there are a number of more or less fragmentary coccosteid remains in the Buffalo museum. Those from the Rhinestreet shale, listed below, perhaps belong to *C. parvulus*, but there is no proof of this at the present time.

a. Specimens from the Conodont bed, at Eighteen Mile Creek, near North Evans, N. Y.; collected by W. L. Bryant.

E 2375 A very small antero-dorsolateral, imbedded in matrix, representing a species about the size of *Coccosteus parvulus*. The width of the element is 13 mm.; its length at the process, 6.5. It shows the areas for overlap by the dorso-median and lateral plates. A lateral line is present; it extends from the articulating process, is somewhat curved, and is especially well-shown on the posterior half of the element.

We refer this specimen provisionally to *Coccosteus*, but it may represent an immature individual of some other Arthrodire.

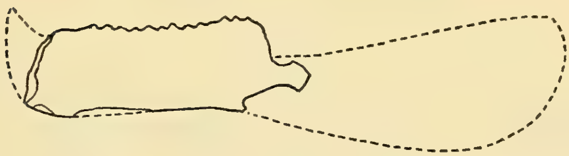

FIG. 4. *Coccosteus* sp. ANTERIOR HALF OF A MANDIBLE, NATURAL SIZE
Its restored outline is indicated by the broken line. E 2378.

E 2376 A postero-ventromedian, in matrix, shown in outer view (Pl. 4, fig. 5). It is ornamented with very small, pointed stellate tubercles, which are largest near the centre of the plate and gradually decrease in size and finally disappear toward the margins. Length in antero-posterior diameter, 40 mm.; greatest width, 30.

E 2377 A postero-ventromedian, on a piece of matrix, shown in inner view (Pl. 4, fig. 4). The outer face, as appears from an impression of a corner of the plate, is ornamented with fine tubercles.

b. Specimens from the Rhinestreet shale (Portage); Eighteen Mile Creek, N. Y.

E 2378 Functional portion of a small mandible lacking the "beak" (fig. 4). The entire functional margin is preserved; it shows a row of teeth extending over its entire length, except at the anterior extremity. The teeth are worn and not well-preserved. The margin back of the functional area drops abruptly down to meet the blade portion. Length

of cutting edge, as far as preserved, 28 mm.; depth of blade, 11. About 13 teeth can be counted. It is probable that this mandible belongs to our *Coccosteus parvulus.*

E 2505 A thin plate traversed by a branched lateral line, represented by the impression of its outer, ornamented face. The ornamentation is finer than in the type specimens of *Coccosteus parvulus*, and the plate perhaps belongs to a different species. Collected by W. L. Bryant.

Dinichthys terrelli Newberry

(Pl. 6, figs. 1–3)

This, the type species of the genus, is represented in the collection by a mandible and a plate, found separately. They are from the type locality, the Cleveland shale (Upper Devonic), at Linndale, near Cleveland, Ohio; and, like all the other specimens from this formation described in the catalog, were collected by Mr. Bryant, in August, 1914.

E 2379 A fine left mandible, in splendid preservation (Pl. 6, figs. 2, 3). A photograph of this specimen was compared with a very fine left mandible in the American Museum (No. 15 Newb. Coll.) which was figured by Newberry[12] himself as representing this species; and it agrees well with it in size and general form. The beak is pointed, and there are three vestigeal denticles at the posterior end of the cutting blade, of which the most anterior one is the largest.

Measurements	*cm.*
Total length	48.5
Length of functional portion	24.0
Height at tooth	16.0
Height at posterior end	22.0

E 2380 Impression of a very large right suborbital (Pl. 6, fig. 1). When found the bone itself was present, but this was badly shaken up, and partly lost in transportation, so that on

[12] *Rept. Geol. Surv. Ohio, Palæont.*, pl. ii, chart 5, fig. 6, 1875.

reaching the laboratory it was completely removed and a cast taken of the impression in the rock. A photograph of this specimen was compared with two suborbitals in the American Museum (Nos. 7298 and 7306 Newb. Coll.), which were figured by Newberry as of *Dinichthys terrelli*.[1] It agrees with these except that it is even larger.

Measurements	*cm.*
Total length (including process)	57.0
Length of body of plate	41.0
Greatest height of body of plate	27.5

Dinchthys intermedius ? Newberry

E 2499 Impression of an antero-ventromedian (fig. 5), probably referable to this species.

Cleveland shale; Linndale, near Cleveland, Ohio. Collected by W. L. Bryant, 1914.

Median ventral plates of *Dinichthys* are rather rare. Of those belonging to the Ohio species there are probably not more than a dozen all told in collections, notwithstanding that collecting has been going on for nearly half a century.

As seen from the figure, the present plate is bilaterally symmetrical, tapers to a point, and was without question distinct from the postero-ventromedian. It is known that in some species of *Dinichthys*, e.g., in *terrelli*, the antero- and the postero-ventromedians were fused into a single elongated plate, whereas in other species, for instance, in *intermedius*, the antero- and the postero-ventromedians were separate plates, the antero-ventromedian narrowing posteriorly, and its extremity fitting into a socket on the outer face of the front end of the postero-ventromedian. The present specimen clearly belongs to the type which has the antero- and postero-ventromedians distinct; and from its size it would appear to belong to *Dinichthys intermedius*. We have compared it with three more or less perfect examples of this plate in the American Museum collections. There is a good deal of variation among these plates, and the present specimen differs somewhat from all with which it has been compared, although in its general form and proportions it agrees pretty well with one of these specimens, also supposed to belong to *Dinichthys intermedius*.

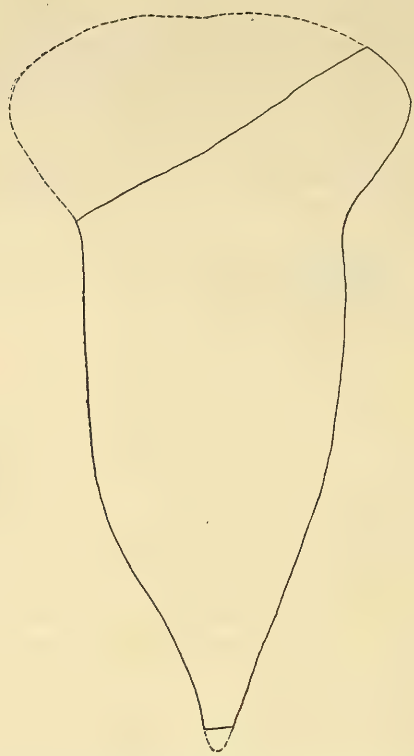

FIG. 5. *Dinichthys intermedius ?* Newberry. OUTLINE OF THE IMPRESSION OF AN ANTERO-VENTROMEDIAN. × ½. E 2499

Dinichthys intermedius ? Newberry

E 2033 A pair of rather small mandibles (fig. 6), associated with several fragmentary *Dinichthys* plates, in outer view, on a slab of shale. The mandibles measures 17.5 cm. in length, and 6 cm. in height (at the beak); and the beak of the right mandible overlaps that of the left. The cutting margins are not well preserved, but can be made out for their entire length; there are no denticles preserved on the posterior portion of the functional margin.

Rhinestreet shale (Portage); shore of Lake Erie at Sturgeon Point, Erie County, N. Y. Collected by F. K. Mixer.

At a first glance these mandibles look rather peculiar, and Eastman (*Bull. Museum Compar. Zoöl.*, xxxi, 31) thought that "their affinities are probably with *Dinichthys minor*." This was before the mandible of the latter had been described. But as was shown by Hussakof,[13] the *minor* mandible is markedly different from that of *Dinichthys*, so much in fact, that it represents a distinct genus, which he named *Brachygnathus* (subsequently renamed *Hussakofia*

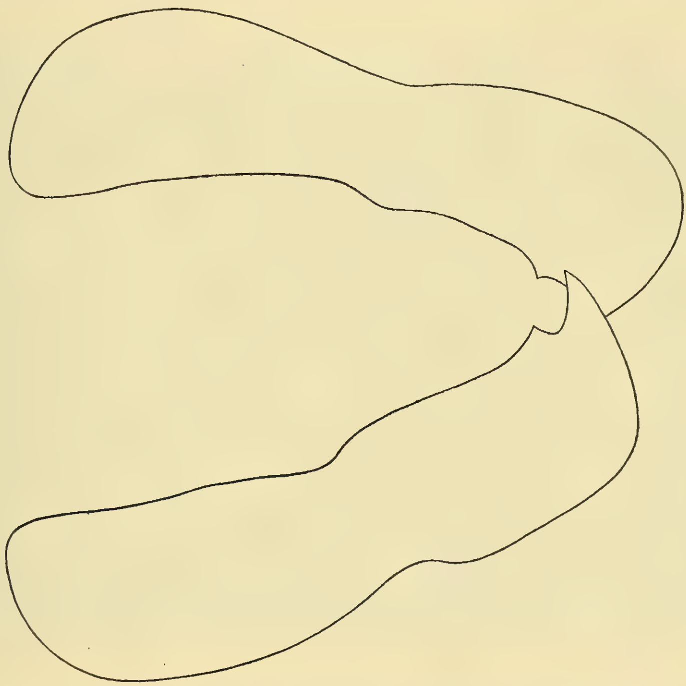

FIG. 6. *Dinichthys intermedius ?* Newberry. PAIR OF MANDIBLES. × ½.
E 2033

by M. Cossman).[14] The present mandibles are not of this type but undoubtedly belong to *Dinichthys*.

If we compare the mandibles in detail with those of various species of *Dinichthys*, we find that they agree fairly well in proportions with those of *D. intermedius* Newberry, and perhaps represent an immature

[13] Hussakof, L.: The systematic relationships of certain American Arthrodires. *Bull. Am. Mus. Nat. Hist.*, xxvi, 263–272, with pl. xlv. 1909.
[14] Cossman, M., in *Rev. Critique de Paleo*, 1910, p. 74.

specimen of this species. Their unusual appearance is due to their little wear by use, the beak still retaining its juvenile pointed condition, and the excavation back of it, produced by the upper "tooth," being still but little worn down.

If we compare the mandibles with the figures of those of *Dinichthys intermedius* given by Newberry (*Paleoz. Fishes of N. A.*, 1889, Pl. x), we find them closely similar to the latter. Thus, the functional part is somewhat shorter than the blade portion; the depth of the functional portion, at its middle, is contained 1⅕ times in the depth of the blade portion, at its middle; and the depth at the junction of the blade and functional portions (measured from the upper point of junction) is contained 2⅓ times in the length of the blade portion. These proportions correspond so closely with those of the mandible of *Dinichthys intermedius*, as to lead us to believe that the present specimens probably belong to this species.

Dinichthys magnificus, n. sp.

(Pls. 1, 7, 8, 9; Pl. 17, fig. 3; Pl. 22, fig. 1; text-figs. 7, 8, 9, 11, 12)

The most impressive and perhaps most valuable specimen of the entire collection in the Buffalo museum, is a magnificent head and body armor of a large species of *Dinichthys*. It was found in a huge concretion (fig. 7) derived from near the base of the Rhinestreet shale. A portion of the concretion was discovered by Mr. Frederick Houghton, of the Buffalo museum, and the remainder, which had drifted out of place, was found the following year by Mr. Bryant. The specimen exhibits the head and most of the body plates of a huge *Dinichthys*. Several of the plates were extricated from the matrix, others were carefully copied in plaster, or squeezes were made of those represented by impressions, and the whole has been set up in a restoration which makes a splendid exhibition specimen (Pl. 1). It is clear that the species is different from any other known, and we therefore describe it here as new.

E 2381 *Type.*—Head and body armor of a large *Dinichthys*, in a concretion. The plates present are shown in figure 8, in which the specimen is represented as if laid out flat. The parts preserved are the head shield; a complete sclerotic ring, composed of four segments, a fragment of the

right subórbital; the larger part of the left mandible; an imperfect antero-superognathal; impression of a postero-superognathal; larger portion of the dorsomedian; an anterior, and both posterior ventrolaterals; the postero-ventromedian; a spine-like element, and portions of a lateral or ''clavicular'' plate.

Formation and Locality.—Basal concretionary portion of the Rhinestreet shale (Portage); Eighteen Mile Creek, near Hamburg, Erie County, N. Y. Collected by W. L. Bryant and Frederick Houghton.

Fig. 7. Concretion Containing the Type of *Dinichthys magnificus*, as Found Near base of Rhinestreet shale (Portage); Eighteen Mile Creek, near Hamburg, N. Y.

A species as large as *Dinichthys terrelli*, ornamented with very small, and mostly closely-crowded, non-stellate tubercles; distinguished especially by the forms of the head and the mandible. Head narrower anteriorly than in any other species; its outline, when viewed from above, sub-triangular; preorbital margin rounded; median occipital short but very broad, and tripartite along its anterior margin. Lateral lines traversing the preorbital gently curved outward at their anterior extremities and not reflexed into curves concave toward the

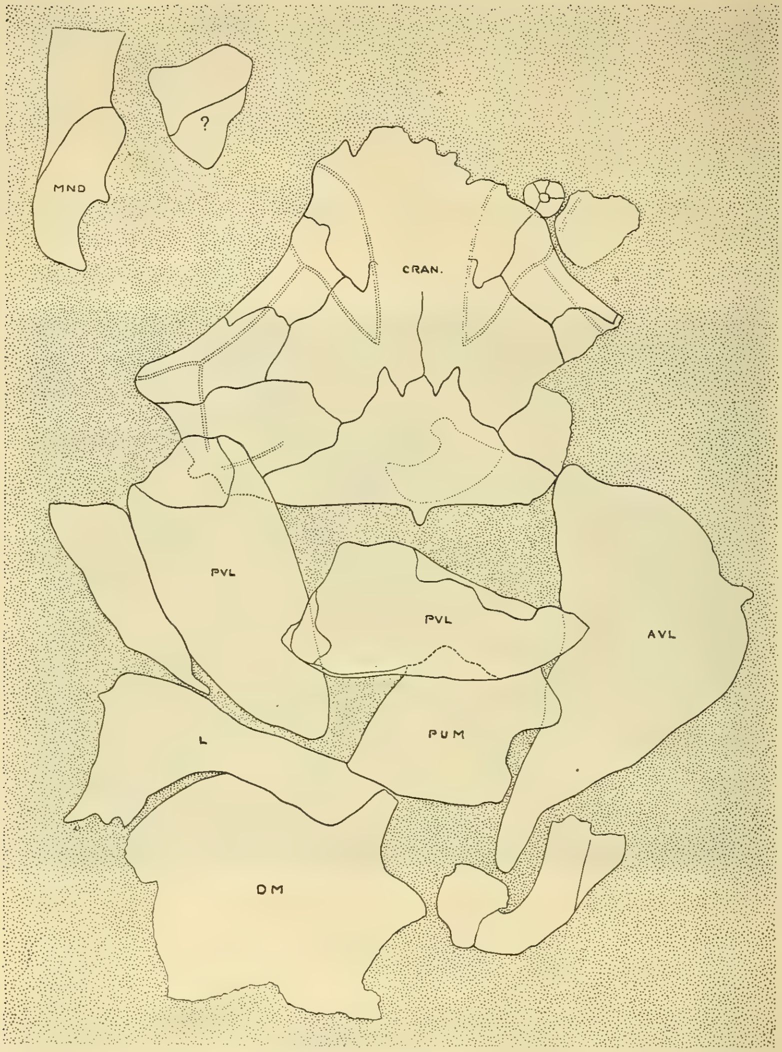

FIG. 8. *Dinichthys magnificus*, n. sp. OUTLINE OF PLATES SHOWN IN THE TYPE SPECIMEN. × 1/9. E 2381

AVL, antero-ventrolateral; *CRAN*, cranium. (Near right orbit is the complete sclerotic ring of that side). *DM*, dorsomedian; *L*, one arm of lateral, or "clavicular;" *MND*, mandible; *PVL*, postero-ventrolateral; both plates are preserved. *PVM*, postero-ventromedian.

median line. Eye surrounded by a sclerotic ring composed of four segments. Mandible of the usual *Dinichthys* type; distinguished by the great distance between the beak and the secondary cusp, the latter being situated toward the middle of the cutting margin.

Remarks.—This species is one of the largest dinichthyids known. It can be compared in size only with *Dinichthys terrelli* of the Cleveland shale of Ohio, from which, however, it is strongly differentiated. It proves that the Ohio dinichthyids were not the only large Arthrodires that existed in late Devonic times, but that coevally with them there lived in the Portage sea of New York, a *Dinichthys* equally huge and powerful.

The following is a detailed account of the plates displayed by the type specimen:

Cranial shield (fig. 9).—The head is fairly well-perserved, most of the bone being present, and the sutures and lateral lines can be clearly made out. The only parts missing are the rostral and a portion of the right side. Owing to the favorable conditions of its fossilization, in a concretion, the head is but little crushed down, and shows considerable arching from side to side.

Its most noteworthy feature is its narrowness anteriorly (compare figs. 9 and 10), so that when viewed from above it appears much more triangular than the cranial shield of *D. terrelli*, or in fact that of any other species known.

The median occipital element is very short antero-posteriorly, but extremely broad, being greatly extended laterally at each side; anteriorly it is divided into three short lobes, a median one and a somewhat narrower one on either side of it.

Another peculiarity of the head shield is to be found in the direction of the preorbital canals. In all species of *Dinichthys* thus far known, these canals have near their anterior extremities, in the region of the rostral element, a secondary curve, concave toward the median line. In the present species there are no such secondary curves, but instead, the anterior moieties of these canals curve outward toward the antero-lateral angles of the head and terminate at the rounded angles anterior to the orbits.

Measurements	*cm.*
Length in median line, with allowance for missing rostral	55
Width across posterior angles of orbits[15]	32
Width across angles of marginals[15]	70

[15] Based on the half preserved.

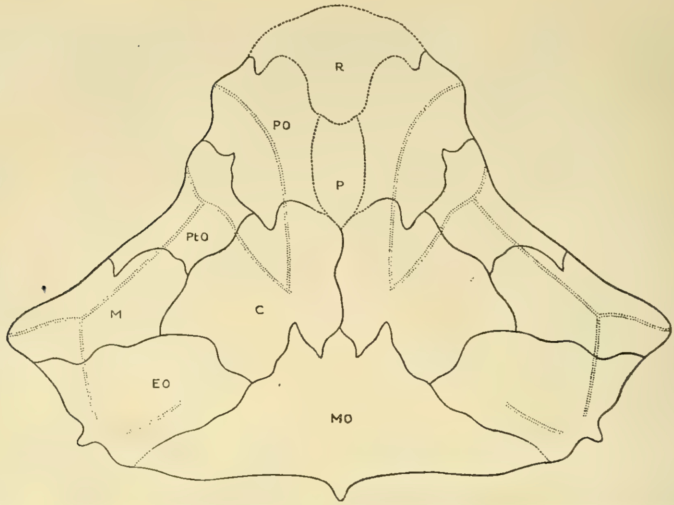

FIG. 9. *Dinichthys magnificus*, n. sp. OUTLINE OF CRANIUM OF TYPE SPECIMEN

The rostral and pineal elements are restored, the former being based on the specimen shown in Plate 17, figure 1. *C*, central; *EO*, external occipital; *M*, marginal; *MO*, median occipital; *P*, pineal; *PO*, preorbital, *PtO*, postorbital; *R*, rostral. $\times \frac{1}{8}$.

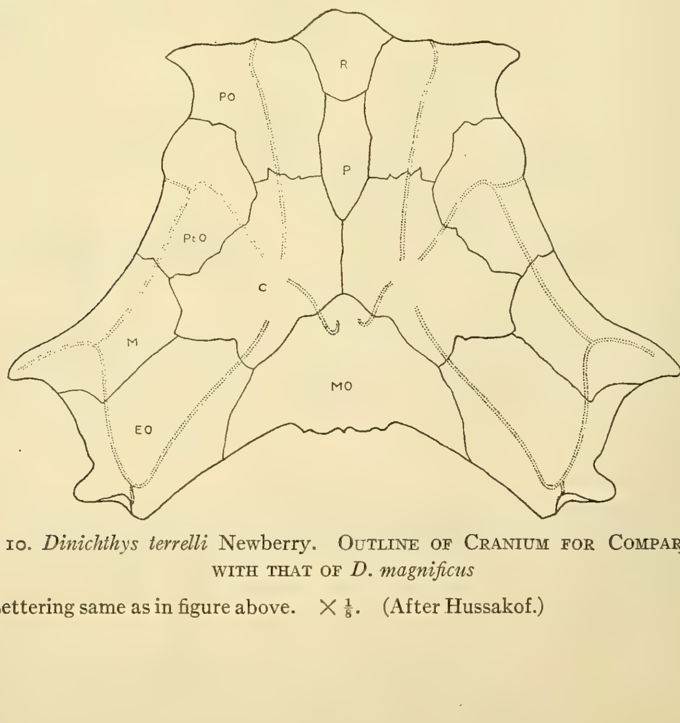

FIG. 10. *Dinichthys terrelli* Newberry. OUTLINE OF CRANIUM FOR COMPARISON WITH THAT OF *D. magnificus*

Lettering same as in figure above. $\times \frac{1}{8}$. (After Hussakof.)

Sclerotic ring (fig. 11).—A feature of great interest in this specimen is the preservation of a complete sclerotic ring, situated near the right orbit, and not far removed from its natural position. It is of great importance as affording for the first time a correct idea of the form of the eye in *Dinichthys*.

Complete sclerotic rings of Arthrodira are extremely rare, owing to the fact that on dissolution of the animal the segments composing the ring became more or less disarranged and usually drifted apart. The most perfect example of an arthrodiran sclerotic ring hitherto known is the one belonging to the type specimen of *Trachosteus*, which was figured by Newberry (*Paleoz. Fishes N. Amer.*, Pl. xlii, fig. 2). It consists of four segments of very thin bone united by wavy sutures so as to form a ring.

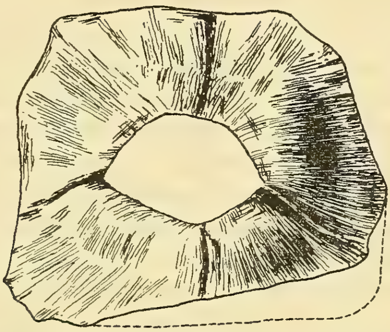

FIG. 11. *Dinichthys magnificus*, n. sp. SCLEROTIC RING, NATURAL SIZE. LOWER MARGIN RESTORED

In the present instance the sclerotic ring is not flattened down but preserves much of its original outward convexity, this convexity representing the configuration of the eyeball, which we thus learn was spherical as in other vertebrates. The ring is composed of four segments; and the opening in the centre, corresponding to the eye proper, is not round but ovate, with the narrow ends drawn out to points. Its form is thus proved to have been much like that of sharks and many other fishes.

The sclerotic ring measures 50 mm. in width, and 11 mm. in height. The eye opening is 20 mm. in long diameter (measured at the lateral angles), and 15 in greatest width.

Mandible.—Only the left mandible is preserved, and this lacks the hinder third. Its form is well shown in the photograph reproduced in

Plate 7, fig. 1, so that no lengthy description of it is necessary. Its outstanding features are the low, broad beak, and the position of the secondary cusp, which is situated far back, near the middle of the functional margin. It is this feature which has enabled us to identify as of this species one or two upper shear teeth, since the groove worn in the sheer plate by the secondary mandibular cusp must be situated farther back in this species than in others.

Antero-superognathal.—The left element is represented; it is badly fractured, the median lateral flange being broken away. The main cusp and the articulating process are however present.

Postero-superognathal.—The left postero-superognathal lay beneath the median occipital, and a complete cast of it was obtained. It is shown in the restoration, Plate 1. There are no posterior denticles and the inner face exhibits a deep groove worn by the posterior mandibular cusp.

Dorsomedian.—Only a portion of this plate is preserved. A cast reconstructed from it measures 15 inches in length, and 17 inches in greatest width. The surface of the plate is finely tuberculated, the tubercles being, if anything, smaller than those of *D. pustulosus.* It is also noteworthy that the plate is strongly arched from side to side, and, like the head shield, apparently suffered little deformation, owing to its favorable preservation in a concretion.

Lateral or "Clavicular."—This element was represented in the opened concretion as an impression, so that a cast could be taken of almost the entire plate. Its form and proportions are clearly indicated in Plate 7, figure 2. The posterior margin measures 25.4 cm. in length, and the inwardly directed arm, 12.6 cm. The outer surface is partially tuberculated.

Ventral Armor.—Of the ventral armor there are preserved the postero-ventromedian, an antero-ventrolateral and both postero-ventrolaterals.

The *postero-ventromedian* (Pl. 22, fig. 1) is shown in the specimen in inner, or visceral view. It is 25.4 cm. in length, and 20.3 cm. in greatest width. It is much wider in proportion to its length than its homolog in *D. terrelli,* and as the anterior end is missing, it cannot be stated whether it was fused with the anterior element into a single ventromedian, as in *D. terrelli,* or was united with it by a socket joint as in most other species.

The *antero-ventrolateral* preserved is that of the left side, shown in inner or visceral view. Its inner margin is broken away. The plate

is arched from side to side, which indicates a more natural condition than usual since ventral plates are very thin and generally found flattened out. A thickened process occurs on the anterior edge which is, apparently, a device for interlocking with the antero-median-ventral. Length of plate, 50.8 cm.; anterior border, about 35 cm.

Both *postero-ventrolaterals* (Pl. 7, fig. 3) are preserved. They are exhibited in outer view and show near the anterior margins, the depressions into which the distal extremities of the corresponding antero-ventrolaterals fitted. The right postero-ventrolateral lacks the front border, but as far as preserved it measures 38 cm. in length, by 17.5 cm. in greatest width. Along the inner margin is an elongated, irregular depression into which the plate of the opposite side fitted, in the manner demonstrated for *Dinichthys* by A. A. Wright.[16] The surface of the plates is finely tuberculated, and along the inner margin the tubercles have a tendency to a linear arrangement.

A knife-shaped spiniferous plate similar to that shown in Plate 17, figure 3, was found overlying the cranium in the orbital region. One end is thickened, the other is formed into a sharp blade.

In addition to the preceding plates there are fragments of two or three others, too imperfect for description. One is a fragment of a suborbital, lying to the right of the cranium and showing a small part of the lateral line that traverses this plate. Another is a fragment of an antero-dorsolateral, showing the articulating process.

Besides the type specimen there are several plates in the collection which seem referable to this species. They are all from the Conodont bed (Genesee), at Eighteen Mile Creek, near North Evans, N. Y., and were collected by W. L. Bryant.

E 1936 Functional half of a left mandible represented in outer view in Plate 8, figs. 1, 1a, and in inner view, in text-figure 12.

We refer this specimen to *D. magnificus* for the reason that the beak is rather low for a mandible of this size, and the secondary cusp is situated at a considerable distance from it—the two features by which the mandible of this species is especially distinguished. An important character in this specimen is the presence of a row of teeth in the symphyseal region. Only the two lowermost ones

[16] Wright, Albert A.: The ventral armor of *Dinichthys*. *Amer. Geologist*, xiv, 313–320, pl. ix, 1894.

are clearly shown (fig. 12, *s*), the others being weathered away. The lowermost one has a diameter of 3.5 mm., and is situated about midway between the tip of the beak and the basal margin.

Measurements	*cm.*
Height at beak (lower margin slightly restored)	8
Length, as far as preserved	11
Depth of functional portion (slightly restored)	6

E 1960 Posterior blade of a right mandible, a part of it represented only by the impression (Pl. 8, fig. 2).

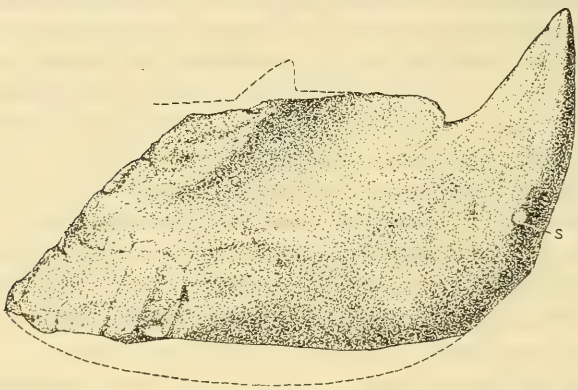

FIG. 12. *Dinichthys magnificus*, n. sp. ANTERIOR EXTREMITY OF A LEFT MANDIBLE, IN INNER VIEW. SYMPHYSEAL DENTICLE. × 3/5. E 1936

This specimen differs somewhat from the blade portion of other dinichthyid mandibles, and perhaps belongs to this species. It is of about the size to go with the functional portion of a mandible described above (E 1936). It is interesting to note that near the lower margin of the blade is a scar apparently inflicted by the teeth of another animal, the plate having been completely bitten through.

E 1937 An imperfect large left postero-superognathal (Pl. 9, fig. 3). The area worn by the secondary mandibular cusp is situated farther back than is usual, thus indicating that the second cusp of the mandible was relatively far back;

and this points to the specimen belonging to *D. magnificus.* Only the proximal portion of the articulating process is preserved.

E 1942 A rather small left postero-superognathal, perfect except for the absence of the articulating process (Pl. 9, figs. 1, 2) Length, 89 mm.; maximum width, 41.

This specimen was found unassociated with other plates. Our reason for referring it to this species is the same as that for the preceding specimens, namely, the fact that the worn edge shows that the secondary cusp of the opposing mandible was situated far back, as in *D. magnificus.* The element resembles E 1937 as far as the preservation of the latter allows of comparison, but it is only about two-thirds its size.

Dinichthys newberryi Clarke

(Pls. 10, 11; text-figs. 13, 14)

This species was originally based[17] on a right mandible, a postero-superognathal and fragmentary cranial plates, all contained in a concretion from the *Styliola* layer of the Genesee, at Bristol Center, N. Y. A dorsomedian plate found at another locality, but in the same horizon, was also referred to by Clarke as probably belonging to this species.

The type, which is preserved in the United States National Museum, was kindly lent us recently for comparison with the material in the Buffalo museum. Since it has never been figured in its entirety, only the mandible having been illustrated by Clarke, and subsequently by Eastman,[18] we deem it desirable to present an outline figure of it here (fig. 13). From this it is seen that there are present in the type specimen the right mandible (*Mnd*), the left postero-superognathal (*PSG*), a section, apparently of one of the antero-superognathals (*ASG*), a segment of a sclerotic ring (*Scl*) and an indeterminate plate (*X*). It is important to note also that a fragmentary plate displayed on the under side of the same concretion, proves that the plates of this species are not, as stated by Eastman,[19] smooth and unornamented,

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[17] Clarke, John M.: *Bull. 16, U. S. Geol. Surv.*, 1885, p. 17, pl. i, fig. 1.
[18] *Mem. 10, N. Y. State Mus.*, 1908, pl. 6, fig. 2.
[19] Loc. cit. p. 133.

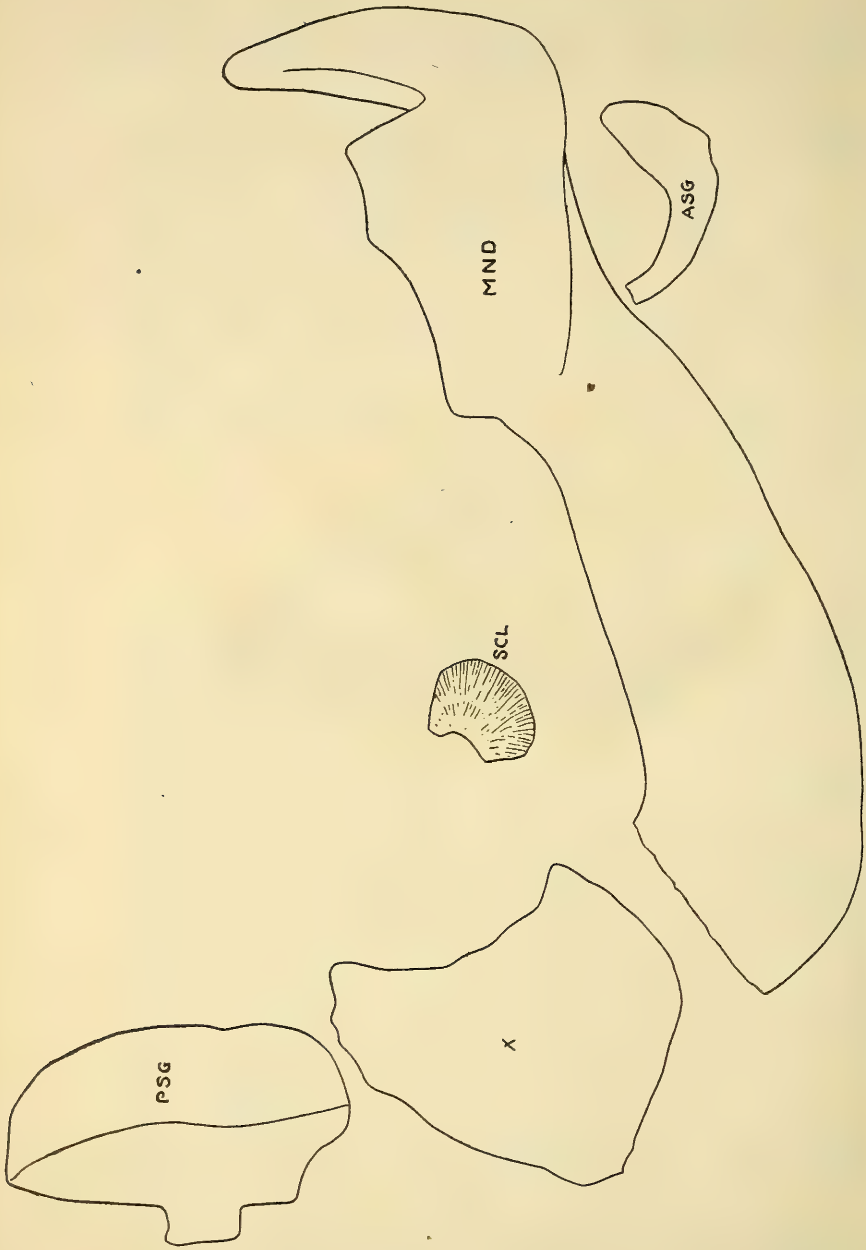

Fig. 13. *Dinichthys newberryi* Clarke. Outline of Plates Shown in the Type Specimen. × ½

ASG, section through an antero-superognathal; *MND*, right mandible, in outer view; *PSG*, left postero-superognathal, in outer view; *SCL*, segment of sclerotic ring; *X*, indeterminate plate. Specimen is in the U. S. Natl. Mus. *Styliola* layer (Genesee); Bristol Center, N. Y.

but bear an ornamentation of fine stellate tubercles very similar to those of *Dinichthys pustulosus.*

We may now record that *Dinichthys newberryi* occurs in the Conodont bed, at Eighteen Mile Creek, where it is found associated with the remains of four or five other species of *Dinichthys.* The remains represented in the Buffalo museum consist of mandibles, upper dental plates, and various more or less fragmentary elements of the head and body armor.

As to the species in which these mandibles belong, there can be no doubt, since they show the elongated beak characteristic of this species.

FIG. 14. *Dinichthys newberryi* Clarke. MOUNTED RESTORATION OF THE DENTITION. × $\frac{1}{3}$

The antero-superognathals, or front upper teeth, range from very small specimens only 31 mm. in height, to large ones equalling those of *D. intermedius,* and which probably represent full-grown individuals. Our reference of these elements to *Dinichthys newberryi* is based on the fact that the worn area on the inner face is unusually long and narrow, thus proving it to have been caused by an elongated mandibular beak of the kind present only in *D. newberryi.*

The ventral plates and the antero-dorsolateral described below, are only doubtfully referred to this species. Our main reason for so referring them is that they bear an ornamentation of fine tubercles somewhat like those seen on the fragmentary plate belonging to the type specimen of *D. newberryi.*

The following specimens are referred—some positively, others only tentatively—to this species. All are from the Conodont bed (Genesee), at Eighteen Mile Creek, Erie County, N. Y., and were collected by W. L. Bryant.

E 2382 Functional half of a left mandible lacking the inferior margin; in matrix, shown in outer view (Pl. 10, fig. 2). The beak is elongated, and back of it there is a smooth, untoothed cutting edge. The front portion of this cutting edge has lost its beveled margin, while the posterior half has not; this produces the illusory appearance of a cusp situated far back on the cutting margin. The full length of the cutting margin is preserved, the break occurring at the beginning of the blade portion. The specimen seems to have been about the size of the type mandible, and as far as preserved agrees with it in character (cf. fig. 13). We think there is no doubt that it is referable to *Dinichthys newberryi.*

Measurements	*mm.*
Total width of functional region, including beak	116
Height of beak (measured on a perpendicular)	40
Width of beak at its base	33
Length of cutting margin (exclusive of beak)	83

E 1939 A left antero-superognathal (Pl. 11, figs. 1, 1a, and text-fig. 15) of about the size to go with the mandible described in the preceding paragraph. This and the following examples of upper dental plates almost positively belong to this species. The element is easily distinguished from other antero-superognathals; first, by the broader and much thinner articulating process, which is very different from the thick process, broadly elliptical in cross-section, seen in *D. terrelli* and related forms; second, by the median lateral portion of the tooth (the opposite side to that of the process) not being so much in-rolled as in the Ohio species.

Measurements	*mm.*
Total height (point of tooth restored)	93
Total width	65
Width of process	31
Length of tooth portion (estimated)	45

E 1940 A left antero-superognathal (Pl. 10, figs. 1, 1a), somewhat smaller than the preceding, and defective on the median part of outer face; it also lacks the tip of the tooth and the distal half of the lateral wing. The articulating process is correspondingly smaller than in the preceding specimen. Height, 86 mm.

E 1955 A juvenile left antero-superognathal, smaller than the preceding (Pl. 11, figs. 2, 2a). It lacks the lateral wing. The tooth portion is long in comparison with the process, a

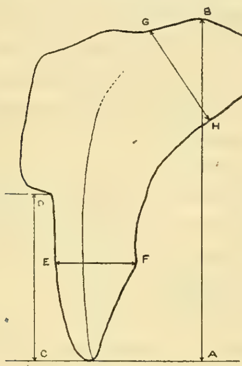

FIG. 15. DIAGRAM SHOWING HOW ANTERO-SUPEROGNATHALS DESCRIBED IN THIS CATALOG WERE MEASURED

A—B, total height; *C—D*, tooth portion of element; *E—F*, width of tooth; *G—H*, width of process. The total width (not indicated by letters), is the extreme width measured along the line, *AC*.

fact also observed in the juvenile antero-superognathals of other species. From the character of the process and the general appearance of the element, it unquestionably belongs to the same species as the preceding three. Height, 31 mm.; greatest width, 17; width of process, 9.

E 1956 A juvenile left antero-superognathal, about one-third the size of the preceding, lacking the tooth and the greater portion of the lateral wing. It agrees closely in general form with the preceding two elements. The process is broad and quite flat. Total height (estimated), 37 mm.; width of process, 14. (Pl. 27, fig. 2.)

E 2383 A left antero-superognathal, lacking the inner flange; in matrix, shown in outer view. Height, 76 mm.

E 1985 An imperfect right antero-dorsolateral. The plate is of fair size and shows the articulating process. The upper surface is much obscured by a very thin deposit of matrix, but the ornamental denticles may be seen in places, and the lateral line is preserved (though it is much obscured), as well as the excavation on the right for overlap by the lateral plate. Posteriorly the element thins out to a paper edge apparently not far from the natural margin.

Length, antero-posteriorly, without process, 13 cm.; width (allowing for missing left margin), about 20.

It seems to us probable, because of its size and the character of the ornamental denticles, that this plate belongs to *D. newberryi*.

E 1986 Postero-medianventral. This specimen is smaller than that of the Portage specimen (E 2032) illustrated in figure 17; and it was clearly not fused with the antero-ventrolateral. (Pl. 28, fig. 3.)

Dinichthys pustulosus Eastman

(Pl. 12; pl. 13, figs. 1, 2)

This species is represented in the collection by material from three different horizons and localities:

1. A number of plates from the typical formation and locality, the Hamilton limestone of Wisconsin. Some of them display the characteristic ornamentation consisting of small tubercles stellate at their bases. Two of the specimens are plates not previously known in this species—the antero-superognathal and the antero-ventromedian.

The antero-superognathal (Pl. 12, fig. 1), may be regarded as a rather primitive, unspecialized example of this element. The inner face (the one bearing the secondary tooth) is broad, the tooth proper is small, and the articulating process short. The other two elements of the jaw, the mandible and the postero-superognathal, have already been described, so that the entire dentition of *D. pustulosus* is now known.

The antero-ventromedian (Pl. 12, fig. 2) is of the form usual for this element. Its outer face is covered with ornamental denticles. It

is undoubtedly a complete plate, and shows that it was articulated, not fused, with the postero-ventromedian.

We figure (Pl. 12, fig. 3) a very perfect example of the right antero-dorsolateral plate of this species. The original, from the Hamilton Limestone of Milwaukee, Wis., is in the private collection of Mr. E. E. Teller, of Buffalo.

2. A number of more or less fragmentary remains from the Conodont bed (Genesee), at Eighteen Mile Creek. These plates are referred to this species with some reservation, since they are all fragmentary and none have been found associated. The principal reason for referring them to this species is the character of their ornamentation; but as a somewhat similar ornamentation occurs in *Dinichthys magnificus*, also found in the Conodont bed, it is quite probable that some of the specimens at least may belong to the latter species. The occurrence of *D. pustulosus* in the Conodont bed is not surprising since the species has been previously recorded[20] from a Genesee horizon, namely the New Albany black shale, near Lexington, Kentucky.

3. Several fragmentary plates from the Genundewa limestone (Genesee), of Eighteen Mile Creek.

a. Specimens from the Hamilton limestone, Milwaukee, Wis. Collected and presented by Mr. Edgar E. Teller.

E 1894 Imperfect dorsomedian showing the keel; one side of the plate is completely preserved. Length in median line, without process, 17.5 cm.; estimated width when complete (measured across widest part) 21.

E 1896 Beak of a right mandible (Pl. 13, fig. 2); it is interesting for showing a vertical row of denticles in the symphyseal region.

E 2384 Cast of a left antero-superognathal in matrix, shown in outer view (Pl. 12, fig. 1). This is the specimen referred to above as the first example of this element in *D. pustulosus* to be made known. Height, including process, 74 mm.; total width, 44. Original in Mr. Teller's private collection.

E 2385 Cast of an antero-ventromedian of a rather small individual (Pl. 12, fig. 2). Length, 10 cm.; maximum width, at

[20] *N. Y. State Mus. Mem. 10*, 1907, p. 133.

front, 5.5. The specimen is of the usual form for this element, and shows the thinning at the lateral margins for overlap by the antero-ventrolaterals. On the inner face the plate is perfectly smooth and bears a low, rounded ridge along the anterior margin, and, extending backward from this down the middle line of the plate, a longitudinal ridge. The outer face of the plate is ornamented, although scantily, with the characteristic tubercles of this species. Original in private collection of Mr. Teller.

b. Specimens from the Conodont Bed (Genesee); Eighteen Mile Creek, at North Evans, Erie County, N. Y. Collected by W. L. Bryant.

E 1973 Left marginal plate of cranium, showing sensory canals (Pl. 13, fig. 4). The plate agrees in form, size and the character of its tuberculated ornamentation with that of *Dinichthys pustulosus*, and, in the absence of evidence to the contrary may tentatively be placed in this species.

E 1974 Imperfect suborbital, showing sensory canal.

E 1975 Incomplete cranial plate bearing sensory canals.

E 1976 A spiniferous plate. This element is of similar form, though much smaller size, than the one figured by Newberry (*Paleoz. Fishes N. Am.*, 1889, Pl. v, figs. 4–5) in *Dinichthys intermedius*. It is tuberculated on its outer surface, and measures 9.5 cm. in length and 1.5 cm. in width.

E 1977. An incomplete ventral plate.

E 1978 Incomplete plate bearing tuberculated ornamentation.

E 1979 An imperfect plate bearing tuberculated ornamentation.

E 1983 Imperfect median occipital of cranium.

c. Specimens from the Genundewa limestone (Genesee); near mouth of Eighteen Mile Creek, Erie County, N. Y. Collected by Mr. F. K. Mixer.

E 1980 Right postero-lateral margin of a cranium, showing a branching sensory canal. This plate was referred to by Eastman (*Bull. Mus. Compar. Zool.*, 1897, xxxi, 40) as a suborbital, and the specimen was erroneously attributed to the Encrinal limestone.

E 2026 About half of a large ventrolateral plate, 21 cm. in greatest width, and about the same dimension in length, which probably belongs to this species. It bears an ornamentation of stellate tubercules, somewhat variable in size. This plate was briefly described by Eastman (*Bull. Mus. Comp. Zool.*, 1897, xxxi, 40) who regarded it as very probably belonging to *D. pustulosus*. It was originally attributed to the Encrinal limestone, but an examination of the matrix convinces us that it is from the Genundewa limestone (Genesee).

Dinichthys insolitus, n. sp.

(Pl. 27, fig. 3)

E 2387 *Type.*—A small right antero-superognathal; total height, 39 mm.; width at middle of tooth portion, 8; width of process, 18.

Formation and Locality.—Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Antero-superognathal small and slender; articulating process broad, flat, and not thickened. External face without denticles. Inner vertical margin a sharp edge with no trace of a secondary, or inner, cusp. Outer lateral margin with an excavation for receiving proximal end of the postero-superognathal; this excavation occupying about one-half the total height of the element, and beginning nearer tip of tooth than upper end.

Remarks.—This is a well-marked species readily distinguished from all others by the absence of the secondary cusp, and by the remarkable excavation for interlocking with the postero-superognathal. In its slender form and in having a broad, flat process, the element is somewhat suggestive of *D. newberryi*; but in the latter a well-marked secondary cusp is present, and the posterior margin of the tooth is not

excavated for interlocking with the postero-superognathal. Moreover, as compared with a juvenile postero-superognathal of *D. newberryi* of about the same size, the present element is more slender, has a stronger angle between the tooth and the process portions, in profile view; and the inner face of the process is excavated, instead of being almost flat.

Dinichthys sp. (Mandible)

(Pl. 70, fig. 3)

A *Dinichthys* mandible of about the size of that of *D. curtus* was recently collected from the Chemung rocks near the city of Erie, Pa., by Mr. E. J. Armstrong, an engineer and student of invertebrate fossils. He has kindly presented it to the Buffalo Museum. This is the first *Dinichthys* mandible to be found in the Chemung, and it seems to differ somewhat from other *Dinichthys* mandibles, so much, in fact, that we believe when an example of it clear of matrix is obtained, it will probably turn out to be a new species, for which we would propose the name *D. Armstrongi* be reserved. As the specimen is embedded with its outer face in the rock so that the form of the functional region is not shown, and since the absence of the posterior extremity must leave it a little doubtful as to the exact length of the entire mandible, we deem it best not to name it at this time. The specimen may be described as follows:

E 2598 A left mandible (Pl. 70, fig. 3), in matrix, shown in inner view. The posterior end is lacking. The beak is rather more recurved than in *D. curtus* or *D. intermedius*. The second cusp also is rather farther back than in these species.

	cm.
Length as far as preserved	22
Estimated total length	26
Length of functional portion (measured to its junction with the blade portion)	13

Numerous fragments of *Dinichthys* plates have been obtained from the Chemung rocks—portions of crania, and dorsal and ventral plates—but, with one exception, all have been too fragmentary for description. There is a large series of such remains in the New York State Museum, at Albany, N. Y., the best of which were at one time sent

to one of us (Hussakof) for study, through the kindness of Director John M. Clarke. Among them was one especially noteworthy—the left margin of a cranium about as large as that of *D. curtus*, or of a size to go with the present mandible. No doubt complete plates of this species will some day be found.

The mandible is too large to belong to *D. tuberculatus* Newberry, which is known only by a small antero-dorsolateral, ornamented with rather large, stellate tubercles.[21]

Regarding the locality and horizon at which the mandible was found, Mr. Armstrong has kindly supplied the following note:

"The locality is on the east branch of Twelve Mile Creek, in Greenfield Township, Erie County, Pa., 200 yards south of the township line. The layer from which it came is approximately 100 feet above the base of the Chemung. The shells on the slab are principally *Productella lacrymosa*, very poorly preserved. *Spirifer disjunctus*, *Camarotoechia contracta*, and *Leiorhynchus newberryi* are also present in this layer. All four species are plentiful both above and below this horizon—above, as far up as the strata are exposed; below, as far as the base of the Chemung. There are of course many other species, but they are not so persistent."

Dinichthys tenuidens, n. sp.

(Pl. 69, fig. 2)

E 2596 *Type.*—A small left mandible, in matrix, shown in outer view. Length, 67 mm.; depth, at end of functional portion, 10.

Formation and Locality.—Rhinestreet shale; Cazenovia Creek, near Willink, N. Y.

Mandible of small size, the functional portion more slender, i.e., not so deep, as the blade, or inserted portion. Functional margin occupying more than half the length of the element; with a slender, pointed beak anteriorly, and a second cusp, also large and pointed, about $\frac{2}{5}$ the length of the cutting margin behind it; part of cutting margin between the two beaks, a sharp, almost straight cutting edge, and this portion of mandible more slender than part back of second cusp.

[*Tenuidens*, in allusion to the slender character of the mandible.]

[21] Newberry, J. S.: *Paleoz. Fishes N. Amer.*, 98, pl. xxxii, fig. 3, 1889.

Remarks.—This small mandible constitutes a well-marked species, easily distinguished by the two widely-separated beaks, and the shallowness of the part of the mandible between them. It differs from all other dinichthyid mandibles by the fact that the cutting margin is longer than the blade, or inserted, portion (measured from its upper junction with the functional part). The mandible as a whole is also rather more slender than is usual in *Dinichthys*; but the presence of two beaks, precludes its being placed in *Stenognathus*.

The specimen may perhaps belong in the same species with the remarkable slender antero-superognathal described on a previous page under the name *Dinichthys insolitus*. But there is no proof of such association, and for the present it is wiser to consider this mandible a distinct species.

Dinichthys sp. (Ventral armor)

(Text-figs. 16, 17)

E 2032 The complete ventral armor of a medium-sized species of *Dinichthys*, on a slab of shale. The specimen is badly weathered, and much of the actual bone is lost; but the outlines of the plates can be made out, and at the posterior end, where the tip of the postero-ventrolaterals is missing, it can be supplied by continuing the outline of the portion of these plates preserved. The antero-ventromedian was obviously a separate plate and not fused with the postero-ventromedian into a single piece. To the right of the antero-ventrolaterals is a small plate, shaped somewhat like an upper tooth; it is, however, a thin plate and shows a centre of ossification. The fragment seen above the right antero-ventrolateral is a portion of an unidentified plate.

Total length of plastron 31 cm.; greatest width, 17.

Portage; Sturgeon Pt., on shore of Lake Erie. Collected by Mr. F. K. Mixer.

This is a very important specimen, being one of the two thus far known which show the entire ventral armor of *Dinichthys* in natural association. The other specimen is that of a small dinichthyid described in 1910 by Burnett Smith.[22] In this the plates were repre-

[22] Smith, Burnett: Notes on some little-known fishes from the New York Devonian. *Proc. Acad. Nat. Sci.*, Philadelphia, lxii, 656–663.

sented only by their impressions in half of a small concretion. Two or three less complete ventral armors of *Dinichthys* are also known; first, that described by von Koenen[23] in 1895, in which the left half of the plastron is preserved; second, a much more complete armor consisting of an antero-ventrolateral and both postero-ventrolaterals, associated with other remains of a single specimen of *Dinichthys curtus*, described by Hussakof in 1905.[24]

The present specimen was discussed at some length in 1897 by Eastman,[25] who tried to determine the species from a consideration of the known relations in size between the mandible and the ventral plates in some dinichthyids. He conlcuded that the specimen might provisionally be referred to *D. newberryi*. But it seems to us, after a careful study of both the specimen and this discussion, that the matter is altogether too hypothetical for a definite conclusion, and that there is no use in this fine-spun reasoning since it cannot lead to anything *positive*. For our part, we are content to describe the specimen as a plastron of *Dinichthys*, without referring it to any one species. If *D. newberryi* were the only species of *Dinichthys* in the Portage shales, we would be justified in thinking that the present plastron belonged to it; but since there are one or two other species, as shown by fragmentary remains, there seems little justification for associating the plastron with one of these rather than with another. The discovery in the Portage of ventral plates in association with other remains may, at any time, upset any mere theoretical conclusions on this point.

Figure 16, represents the plastron as it appears in the slab, and figure 17, is a restoration of it. On comparing the two figures it will be seen that there is very little that is conjectural in our restoration. It is, in fact, hardly more than an outline drawing of the plates shown in the specimen, with here and there a missing portion of the outline added.

On comparing our restoration with that given by Eastman[26] of the same specimen it will be seen that there is considerable difference between the two. In our restoration the postero-ventrolaterals are broader and shorter, and united in the median line by small flanges

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[23] von Koenen, A.: Ueber einige Fischreste des norddeutschen und böhmischen Devons . . . *Abhandl. k. Gesell. Wissen.* Göttingen, xl, 1–37, pls. i–v.

[24] Hussakof, L.: On the structure of two imperfectly known Dinichthyids. *Bull. Amer. Mus. Nat. Hist.*, xxi, 409–414, pls. xv–xvii and 2 figs.

[25] Eastman, C. R.: On the relations of certain plates in the Dinichthyids, with descriptions of new species. *Bull. Mus. Comp. Zool.*, xxxi, 19–44, pls. i–v.

[26] Loc. cit., pl. i, fig. 2.

instead of merely overlapping to the extent of about one-fourth the width of one of these plates. The anterior median-ventral differs in shape; the postero-ventromedian does not extend so far back; and

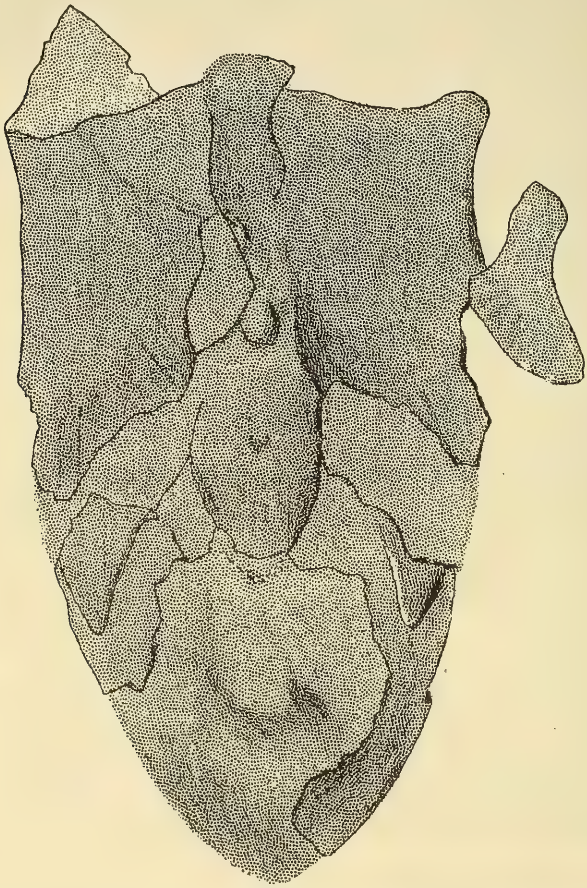

FIG. 16. *Dinichthys* sp. VENTRAL ARMOR OF A MEDIUM-SIZED SPECIES, MUCH WEATHERED. × $\frac{1}{3}$. E 2032

the anterior processes of the antero-ventrolaterals are shorter and broader, giving these plates a different aspect. We believe there is ample justification for all these details in the specimen.

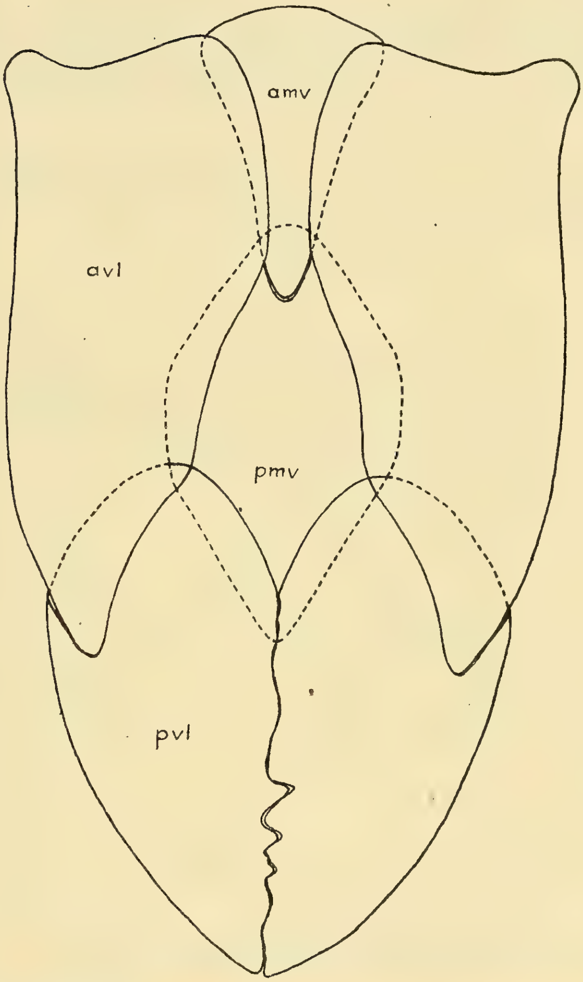

FIG. 17. *Dinichthys* sp. – RESTORATION OF VENTRAL ARMOR SHOWN IN FIGURE 16. × ½

amv, antero-medianventral; *avl*, antero-ventrolateral; *pmv*, postero-medianventral; *pvl*, postero-ventrolateral.

Dinichthys sp.

In addition to the specimens of *Dinichthys* referred to various species in the preceding pages, there are a considerable number of remains that are at present specifically indeterminable. Some of them no doubt belong to *D. newberryi*, others to *D. magnificus*, and a few perhaps represent juvenile individuals.

1. Specimens from the Conodont bed, (Genesee), at Eighteen Mile Creek, Erie County, N. Y.; collected by W. L. Bryant.

a. Cranial plates

E 1981 Rostral element of a small cranial shield (Pl. 17, fig. 1). It is ornamented with minute tubercles, much smaller than those of *Dinichthys pustulosus*, grouped partly into vermiculating, ridge-like rows. We have used this element as a guide in restoring the front of the head of *Dinichthys magnificus* in text-figure 9.

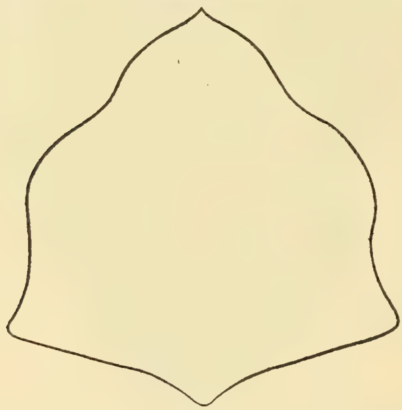

FIG. 18. OUTLINE OF A MEDIAN OCCIPITAL OF AN INDETERMINATE SPECIES OF *Dinichthys*. × ½. E 2008. (See Pl. 19, fig. 2.)

E 1994 External occipital showing sensory canal and articulating socket.

E 2008 Median occiptal. (Pl. 19, fig. 2; text-fig. 18). The ornamentation consists of fine tubercles with a linear arrangement, radiating from the centre of the plate, and recalling the ornamentation of *Holonema* (*Glyptaspis*) *abbreviatum*.

b. Suborbitals

E 1984 Anterior portion of a right suborbital, showing sensory canal; without ornamentation. The plate is comparable in size with its homolog in *Dinichthys newberryi*, and perhaps belongs to that species.

E 1992 Suborbital of a small dinichthyid.

E 2001 Imperfect suborbital showing sensory canal; ornamented with fine tubercles. It probably belongs to the same species as the preceding.

c. Mandibles.

E 2510 Functional portion of a right mandible of a species about the size of *D. newberryi* (Pl. 14, fig. 2). The blade portion is broken away and the oral margin is deeply excavated, probably through wear. The mandible seems to have belonged to an old individual. The beak, however, is sharp and prehensile; its outer surface shows the bevelling produced by the play of the antero-superognathal against it. The inner surface of the beak is hollowed out. It is therefore much weaker than most dinichthyid mandibular cusps, and in this respect and in its slender proportions the mandible resembles that of a very large *Stenognathus*.

E 1941 Beak of a right mandible.

E 1948 Portion of the cutting blade of a small mandible.

d. Antero-superognathals

E 1951 A very small left antero-superognathal (Pl. 18, fig. 1), the smallest element of the kind ever found. Its height is 8 mm.; width, 11. It is, of course, not known what species it represents.

E 1952 Two small right antero-superognathals, perhaps young of *Dinichthys newberryi*.

E 1954 A small right antero-superognathal which may represent a juvenile individual of *D. magnificus* (pl. 27, fig. 1). It differs from the juvenile antero-superognathal of *D. newberryi* in that the anterior face joins the outer lateral face in a sharp ridge, instead of the two being confluent in a convex plane as in juvenile antero-superognathal of the latter. The fang also is relatively sharper and more pointed. Height, 4 cm.

E 1958 "Tooth" of a left antero-superognathal of about the size of *D. newberryi* (Pl. 13, fig. 3. By inadvertance this figure is upside down.)

e. Postero-superognathals

The following two postero-superognathals are clearly referable to *Dinichthys*. They are small, but judging by the amount of wear of the functional margin, they both probably represent adult individuals. The inferior margin is in both strongly rounded; and they differ in form from any other postero-superognathals hitherto described. None the less, we hesitate to base a species upon them, since they may belong with some of the other *Dinichthys* remains for which we have proposed names in the preceding pages.

E 1943 A small right postero-superognathal, 65 mm. in width (Pl. 16, figs. 1, 1a). The inferior margin is more rounded than is usual in *Dinichthys* postero-superognathals. The functional margin, on the inner face, is beveled by wear. Five denticles are present along the posterior end of the cutting margin, which increase somewhat in size distalward.

Measurements	*mm.*
Greatest width	65
Total height, including process	50
Greatest height from cutting margin to line separating lower from upper half	29

E 2388 A right postero-superognathal of the same species as the preceding but smaller; in matrix, shown in inner view (Pl. 16, fig. 2). Greatest width, 56 mm.; total height, including process, 36.

f. Dorsal and lateral plates

E 1998 Half of a postero-dorsolateral, ornamented with small, non-stellate tubercles on the non-overlapped portion (Pl. 13, fig. 5).

E 2004 Antero-dorsolateral of a small dinichthyid, finely tuberculated.

E 1991 Portion of a lateral or "clavicular" plate.

g. Ventral plates

E 1989 Portion of a small ventral plate, without ornamentation.

E 1990 Imperfect postero-ventrolateral (?) of a small dinichthyid, without ornamentation.

E 1993 Antero-ventromedian of a small dinichthyid.

E 2000 Ventral plate of a small dinichthyid, finely tuberculated.

E 2002 Ventral (?) bearing fine tuberculation; same species as preceding.

E 2389 A juvenile right antero-ventrolateral (Pl. 18, fig. 2). The plate is very thick for a specimen of such small size, but the same condition was observed by us in one or two other small specimens, and is, perhaps, a characteristic of juvenile ventral plates in some species. The outer face is ornamented with small non-stellate tubercles, which are especially well-shown on the posterior half of the plate, where the outer surface is well-preserved; on the anterior half of the plate, the external surface is somewhat abraded and no tubercles are preserved.

Length, 114 mm.; greatest width (slightly restored) 43; maximum thickness (at about one-third the length of the plate from the anterior margin and near the outer half), 13.

h. Fragmentary plates

E 1996 Incomplete plate of a small dinicthyid, ornamented with stellate tubercles rather larger than those of *Dinichthys pustulosus.* (Pl. 17, fig. 2).

E 1997 Fragmentary plate, ornamented with smaller tubercles than the preceding (Pl. 17, fig. 3).

E 2003 Finely tuberculated plate.

FIG. 19. CUSP, OR "TOOTH," OF RIGHT MANDIBLE OF A SMALL SPECIES OF *Dinichthys*, OUTER VIEW. NATURAL SIZE. E 2038

E 2011 Fin-ray (Pl. 18, fig. 3), resembling those figured by Newberry (*Paleoz. Fishes N. Amer.*, Pl. vii, fig. 1). The specimen is similar to one found in association with the type of *D. magnificus* and perhaps belongs in that species.

E 1987 A small, fragmentary plate without ornamentation.

2. Specimens from the Rhinestreet shale (Portage); shore of Lake Erie at Sturgeon Point, Erie County, N. Y.; collected by F. K. Mixer.

E 2035 An imperfect plate ornamented with fine tubercles arranged in linear series (Pl. 28, fig. 1). This is perhaps not *Dinichthys* but an allied genus.

E 2036 A small, incomplete antero-ventrolateral.

E 2038 Anterior extremity of a small right mandible, showing the beak and the secondary cusp back of it, in matrix, shown in outer view (text-fig. 19).

E 2511 A postero-ventrolateral apparently not quite complete. The specimen (Pl. 14, fig. 1) measures 11 cm. in length and 8 cm. in greatest width. The anterior margin is practically complete and shows the notch into which the antero-ventrolateral fitted. The specimen is of about the size to go with the complete Rhinestreet shale plastron described on page 56, and there seems little doubt that it belongs to the same species. It was collected at the same locality and horizon.

Titanichthys sp.

(Text-fig. 20)

E 2390 Slab in counterpart, exhibiting portion of a rather small lateral, or "clavicular" plate, and a second, complete but indeterminate plate partly overlying it.

Cleveland shale; Linndale, near Cleveland, Ohio; collected by W.L. Bryant, 1914.

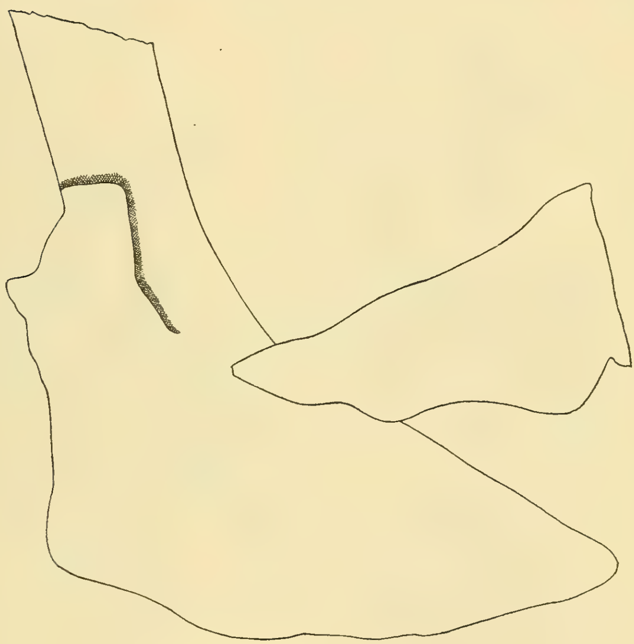

FIG. 20. *Titanichthys* sp. OUTLINE OF ONE ARM OF A LATERAL AND AN ASSOCIATED PLATE. × $\frac{1}{3}$. PRESERVED IN COUNTERPART. E 2390

E 2391 Anterior third of a small right mandible (Pl. 19, fig. 1). In the same concretion and in actual contact with the mandible is a spiniferous plate, or fin-ray, with knife-like blade, similar to those of dinichthyids.

Stenognathus dolichocephalus (Eastman)

(Text-figs. 21, 22)

Dinichthys dolichocephalus C. R. Eastman, N. Y. State Mus., Mem. x, 135, pl. v, fig. 1, 1907.

The unique specimen by which this species is known is preserved in the Buffalo Museum (E 2034). It consists of a small slab of shale containing most of the armor plates and the mandibles of a small Arthrodire. The plates are more or less confused on the slab, most of

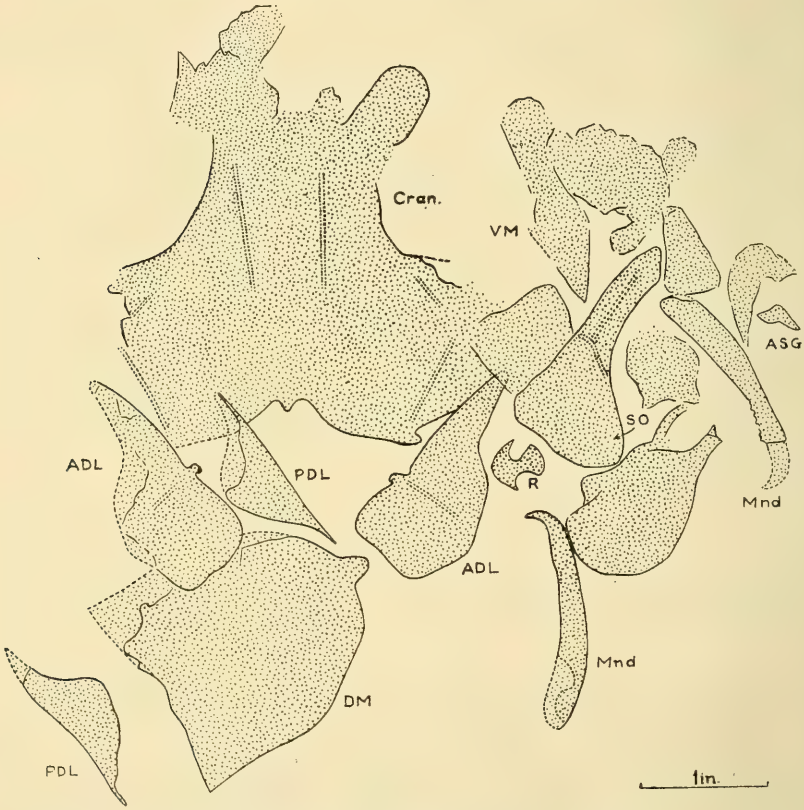

Fig. 21. *Stenognathus dolichocephalus* (Eastman). Type, × about $\frac{5}{8}$. E 2034

Rhinestreet shale (Portage); Sturgeon Point, on Lake Erie, near Buffalo, N Y. *ADL*, antero-dorsolateral; *ASG*, antero-superognathal; *Cran*, cranium; *DM*, dorsomedian; *Mnd*, mandible; *PDL*, postero-dorsolateral; *R*, rostral; *SO*, suborbital; *VM*, ventromedian.

them are poorly preserved, and the actual bone is missing in places; still their outlines can in most cases be clearly made out. We have restudied the specimen, and made a careful tracing of it which is reproduced in figure 21. This represents all that can be made out; we have only omitted, for the sake of clearness, some hazy indications of plates, especially near the right margin of the dorsomedian.

The plates present in the specimen are: the cranial shield, dorsomedian, both antero- and both postero-dorsolaterals, both mandibles,

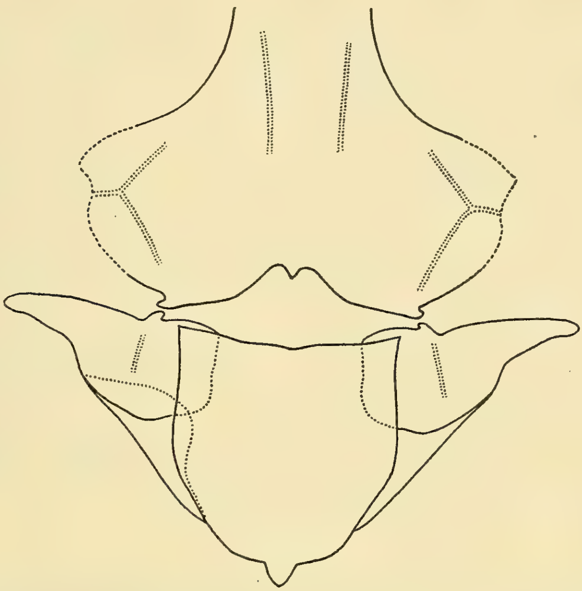

FIG. 22. *Stenognathus dolichocephalus* (Eastman). RESTORATION OF DORSAL ARMOR OF SPECIMEN SHOWN IN FIGURE 21

one antero-superognathal (not mentioned in Eastman's description), a suborbital, a median ventral, and portions of several other plates, perhaps ventrals.

To determine the genus and species to which the specimen belongs, we must obviously look to the mandibles as the most distinctive elements of the animal. Fortunately these are fairly well-preserved. They are much elongated, and anteriorly rise into a beak. Eastman, in his original description of the specimen, decided that the mandibles were of the *Dinichthys* type, and referred the specimen to that genus.

To us, they appear too slender for *Dinichthys*, and rather like the slender mandibles named by Newberry *Stenognathus*.[27] This genus has recently been studied by Hussakof[28] on the basis of a fine specimen displaying most of the remains (including the dentition) of an animal in a concretion from the Cleveland shale, preserved in the British Museum. By the aid of this specimen it was shown that the form named *Dinichthys gouldi* by Newberry, the incomplete mandibles known as *Dinichthys corrugatus* and *Stenognathus corrugatus*, and the complete mandible described by Claypole under the name of *Dinichthys gracilis*, are all one form, to which Newberry's generic term *Stenognathus* is applicable. This genus is especially remarkable for its long, slender mandibles and its elongated postero-superognathal.

If we compare the mandibles of the Buffalo specimen under discussion (E 2034), with those of *Stenognathus*, we see that they are of the same type, thus proving that this specimen belongs in that genus. Moreover, there is a correspondence in other plates which are distinctive for the genus,—for instance, the suborbital, which is roughly triangular, rather than rectangular as in *Dinichthys*. For these reasons it is clear that the specimen belongs in *Stenognathus*.

The specimen was collected by Mr. F. K. Mixer from the Portage, at Sturgeon Point, on the shore of Lake Erie, near Buffalo, N. Y.

Stenognathus ringuebergi (Newberry)

(Pl. 15, fig. 2, Pl. 69, fig. 1)

Dinichthys minor RINGUEBERG, Amer. Journ. Sci., 3 ser., xxvii, p. 476. 1884.
Dinichthys ringuebergi NEWBERRY, Pal. Fishes N. Amer., p. 60. 1889.

This species has hitherto been known only by the type specimen, a dorsomedian plate, in the collection of Mr. E. N. S. Ringueberg, of Lockport, N. Y. We may now record a second specimen collected by Mr. Bryant in the summer of 1916, which very materially increases our knowledge of this form.

Through the kindness of Mr. Ringueberg we have had the privilege of studying and photographing the type plate, and we here give an account of it in the light of present knowledge of this group.

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[27] *Trans. N. Y. Acad. Sci.*, xvi, 30, pl. xxiv, figs. 27–28, 1897.
[28] Hussakof, L.: Upper Devonian Arthrodira from Ohio in the British Museum (Natural History). *Geol. Magazine*, [5], viii, 126, pl. viii, fig. 5 and text-fig. 6, 1911.

A detailed description of the plate accompanied by a pen-and-ink figure was published by Ringueberg in 1884.[29] The plate was correctly identified as a dorsomedian, but was figured upside down—an error excusable at that time when so little was known concerning *Dinichthys* and so few figures were available.

The plate is well represented in Plate 15, figure 2. It is of small size, 11 cm. in length in the middle line (without the process), and 14 cm. in greatest width. Its most distinctive character is the emargination of the front halves of the lateral margins. In this, however, it is not unique, for a dorsomedian of much larger size, from the Cleveland shale, in the American Museum collection, shows the same form. This feature distinguishes these two plates at a glance from dinichthyid dorsomedians. It is possible that the plate belongs to the species we have named *Stenognathus mixeri* (page 75); it is of about a size to go with the type of the latter. However, ventral plates of the latter show a fine tuberculation which is not evident in *S. ringuebergi*. The fact that a similar shaped plate occurs in the Cleveland shale is interesting in view of the occurrence of *Stenognathus* in that formation also.

The plate is embedded in matrix and displays the dorsal, or upper surface. The extremity of the keel, forming the usual dinichthyid "knob" process, is well shown.

Horizon and locality.—Portage shale (Rhinestreet): Sturgeon Point, shore of Lake Erie, N. Y. Collected by Mr. E. N. S. Ringueberg and preserved in his private collection at Lockport, N. Y.

Besides the type just described, we have in hand a remarkable specimen of this species collected by Mr. Bryant in the summer of 1916. The specimen is of great interest for the fact that it shows a part of the notochord, with neural and haemal arches. It is the second specimen of a *Stenognathus* found with the notochordal region preserved. Although no dental elements are preserved in the specimen, still we regard it as belonging to the genus *Stenognathus*, for the reasons that the form of the dorsomedian— especially as shown in the type—excludes it from the genus *Dinichthys*; but the thinness of the ventral plate, coupled with the fact of its size and resemblance to its homolog in *S. gouldi*, would indicate that the specimen belongs in *Stenognathus*.

E 2595 The specimen (Pl. 69, fig. 1), consists of a slab of shale, 65 by 37 cm., displaying the dorsomedian (*DM*), a postero-

[29] Ringueberg, E. N. S.: A new *Dinichthys* from the Portage Group of Western New York. *Amer. Journ. Sci.*, 3 ser., xxvii 476–478, 2 figs.

ventrolateral (*V*), with some fragments apparently of other ventral plates, and, behind these, a part of the notochordal area (*N*) delimited by neural (*n.a.*) and haemal (*h.a.*) arches.

The *dorsomedian* is shown in outer view. Its anterior margin, and the front portion of the right side are gone, but the left side shows the anterior emargination, so characteristic of this species (see figure of type, Pl. 15, fig. 2), and at once enables us to identify the form as *S. ringuebergi.* The posterior process of the plate is also preserved.

The *postero-ventrolateral* present is that of the right side, shown in outer view. It is very thin, thinner proportionally than in a *Dinichthys* of the same size, and where the bone has weathered away, the impression in the matrix shows rings of growth.

The *notochord*—or more properly, the space occupied in life by the notochord—is preserved for a length of 29 cm. It measures 40 mm. in diameter near the anterior end of the preserved portion, and does not, in this portion, at any rate, decrease much in diameter; at the posterior end of the preserved portion it is 35 mm. in diameter. The neural and haemal spines (arches?) are not sharply preserved, although it is seen at a glance that one set, evidently the neural spines, are higher than those of the opposite side, the haemals. This notochordal region resembles that frequently found in specimens of *Coccosteus* from the Old Red Sandstone, except, of course, that it is broader, as it should be in an animal much larger than *Coccosteus*.

The only other example of the notochord in a dinichthyid, is one collected years ago in the Cleveland shale of Ohio, and preserved in the American Museum in New York. This, also, apparently belongs in the genus *Stenognathus*.[30]

Horizon and locality.—Rhinestreet Shale; Eighteen Mile Creek near Hamburg, N. Y. Collected by W. L. Bryant, 1916.

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[30] No. 2454 Amer. Mus. *Trans. N. Y. Acad. Sci.*, xv, 157, pl. vii, 1896.

Stenognathus gouldi ? (Newberry)[31]

(Pl. 15, fig. 1)

E 2392 Anterior half of a right mandible with the beak and cutting edge well preserved. Length, as far as preserved, 82 mm. Height at middle of functional region, 29.

This specimen seems referable to *S. gouldi* (Newberry), of the Cleveland shale of Ohio. It agrees with this form in size and in absence of the symphyseal denticles, the latter present in *S. insignis* and *S. mixeri*, two new species described farther on. If the identification is correct then this species is common to the Cleveland shales and the Conodont bed.

Conodont Bed (Lower Genesee); Eighteen Mile Creek, near North Evans, Erie County, New York.

Stenognathus denticulatus, n. sp.

(Text-fig. 23)

E 2386 *Type.*—A small right postero-superognathal with upper part of outer face covered with matrix; inner face clear. Width 41 mm.; total height, including process, 17.

Formation and Locality.—Conodont bed (Genesee), Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Postero-superognathal small, elongated, its distal half gradually tapering toward the posterior extremity. Outer face ornamented with four or five downward-pointing denticles extending in a row diagonally upward and backward from the middle of the cutting margin; denticles separated from one another by spaces equal to, or exceeding, the width of a denticle, and covered with a shining, enamel-like substance. Inner face concave, except in region of articulating process, which forms a low, rounded, but prominent ridge.

Remarks.—This element is clearly distinct from any other hitherto described. Its elongation antro-posteriorly seems to us to place it in *Stenognathus* rather than *Dinichthys*. The presence of ornamental denticles on the outer face is a very remarkable feature, such

[31] For full synonymy and description of this species see paper by Hussakof referred to in foot-note 28, page 68.

a condition being known in only a few Arthrodira, and in none of them being better shown. The form with which the element can best be compared as regards this feature is *Dinichthys herzeri*, in which the postero-superognathal has a row of ornamental denticles extending diagonally upward across the outer face very much as in the specimen here described.[32] This species is, however, of huge size as compared with the present specimen, and also, the postero-superognathal is not so elongated.

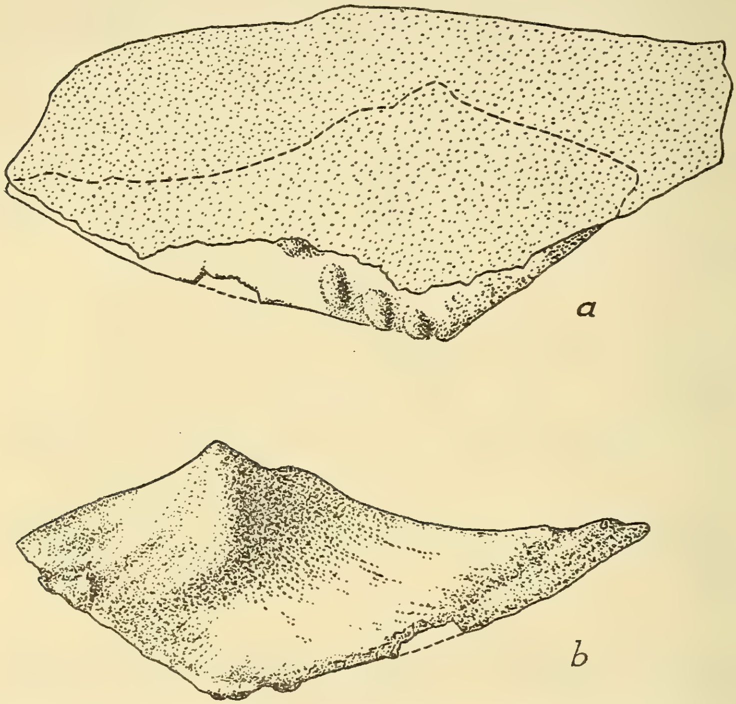

FIG. 23. *Stenognathus denticulatus*, n. sp. RIGHT POSTERO-SUPEROGNATHAL. TYPE, × 2

a, outer view showing the oblique row of denticles. Most of this side of the element is covered with matrix, indicated by the stippling. *b*, inner view. E 2386.

From its homolog in *Stenognathus mixeri* described on p. 75, it is distinguished by its relatively greater elongation and by tapering more to a point in its distal half.

[32] For a figure of the postero-superognathal in *Dinichthys herzeri* see Hussakof, L.: Studies on the Arthrodira. *Mem. Amer. Mus. Nat. Hist.*, ix, pl. xiii, fig. 3, 1906.

Stenognathus insignis, n. sp.

(Pl. 21, fig. 2, and text-fig. 24)

E 1932 *Type.*—A right mandible lacking the posterior half of the inserted portion.

Measurements	*mm.*
Length of functional portion, including beak	80
Depth at middle of functional area	24
Depth of blade portion (2 cm. back of functional part)	25

Formation and Locality.—Conodont bed (Lower Genesee); Eighteen Mile Creek, near Buffalo, N. Y. Collected by W. L. Bryant.

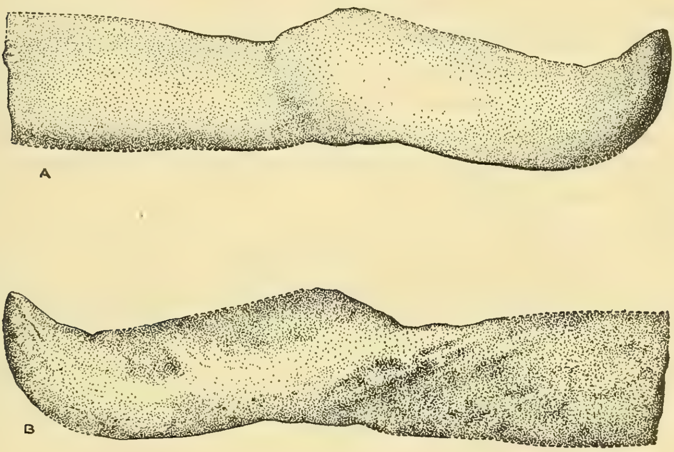

FIG. 24. *Stenognathus insignis,* n. sp. RIGHT MANDIBLE. TYPE, × $\frac{2}{3}$ *A*, outer, and *B*, inner views. E 1932. (See Pl. 21, fig. 2.)

Mandible long and slender, with the anterior functional portion demarcated from the nonfunctional as in *Dinichthys.* A prominent dinichthys-like beak present, but no secondary beak or cusp back of it. Functional margin a continuous knife-like edge, rising gently backward to near the point of its union with the nonfunctional portion of mandible, whence it slopes more abruptly down to merge in the blade portion. Posterior end of functional margin without denticles. Inner face of functional area thins out gradually toward the cutting edge, except near middle of this area, where there is a faint indication

of a ridge rising obliquely upward and forward; this does not, however, rise above the cutting edge so as to form a secondary cusp, as in *Dinichthys*. Symphyseal denticles present (not well-shown in the type).

Remarks.—Besides the type we have three other specimens of this species, from the type locality. In general shape, and in the demarcation of the functional from the inserted portion, these elements are not unlike a *Dinichthys* mandible. But the long, slender form, and the absence of a secondary cusp back of the beak, clearly mark them as belonging to the genus *Stenognathus* as defined by Newberry.

From *Stenognathus gouldi*, the Ohio species, the present form is disguished, first, by the much weaker beak; second, by the presence of symphyseal denticles, whereas in the Ohio species their place is occupied by a rounded vertical ridge, which extends, like the row of denticles, about two-thirds down the height of the blade. In the present species, also, the functional portion is not quite so slender as in the Ohio form; i.e., the mandible of this species is closer to *Dinichthys* than is that of *S. gouldi*.

The other three mandibles of this species (*paratypes*), are from the type formation and locality:

E 1933 An imperfect left mandible, lacking the beak and the posterior half of the inserted portion. It shows well the region of junction between the functional and blade portions, and the excavation along the lower margin of the functional portion for the attaching tissues. This region resembles that in *Dinichthys*. The cutting edge agrees with that of the type specimen in the absence of a secondary cusp.

E 1938 Anterior portion of a mandible. The specimen is somewhat deeper than the type and probably represents an older individual. It shows the symphyseal region well; this is turned inward at right angles to the outer face and terminates in a vertical row of denticles, extending about two-thirds down the symphyseal mârgin. The denticles themselves are missing, but the roots of two of them are clearly shown; the lowermost one is the largest.

E 2506 Inserted portion of a mandible.

Stenognathus mixeri, n. sp.

(Text-fig. 25)

E 2030 *Type.*—A slab of shale 29 by 46 cm., in counterpart, containing both mandibles, an antero- and a postero-superognathal, both suborbitals, portion of a lateral plate, sclerotic segments, and several incomplete cranial and ventral plates.

Formation and Locality. Rhinestreet shale (Portage); shore of Lake Erie, near Sturgeon Point, Erie County, New York. Collected by F. K. Mixer and W. L. Bryant.

Mandible 17.5 cm. in length, long and slender, the functional portion contained $1\frac{1}{3}$ times in the blade portion; greatest depth of functional portion $3\frac{1}{2}$ times in its length. Functional margin with denticles except at its anterior fourth, which is smooth and beveled; denticles about 12 in number, gradually increasing in height backward; largest denticle 3 mm. high. Anterior extremity of mandible rises into a low beak. Symphysis with a vertical row of 7 denticles. Antero-superognathal triangular in outline, with a pointed beak and a small, secondary cusp; upper or process portion of element flattened, thin and not developed into an elongated thickened process as in *Dinichthys*; outer lateral margin of element with 4 or 5 low denticles. Postero-superognathal, elongated, and when found, had a row of denticles along its functional margin. (This element is shown in inner view and is not well preserved.) Plates of cranial shield apparently thin. Suborbital of the form characteristic of this genus, with long slender anterior process and relatively short, somewhat triangular blade portion. Orbit very large.

We take pleasure in naming this species for Mr. F. K. Mixer of Buffalo, long an active member of the Buffalo Society and at one time curator of its museum, to whom students of Arthrodira are indebted for his discovery of numerous localities of fish-bearing rocks in the vicinity of Buffalo. Mr. Mixer and Mr. Bryant were together on a collecting trip at Sturgeon Point, N. Y., when the present specimen was discovered.

Remarks.—This remarkable specimen belongs in the genus *Stenognathus*, a genus distinguished especially by its long, slender mandibles, sub-triangular antero-superognathals, and elongated upper shear teeth. The suboribtals are also characteristic, the orbits being large,

the anterior processes long and slender, while the plate proper is somewhat triangular, rather than quadrangular as in *Dinichthys.*

The type is well illustrated in figure 25. Only the elements referred to in the description above are illustrated, several confused, thin cranial or ventral plates on the slab, to the right of these elements,

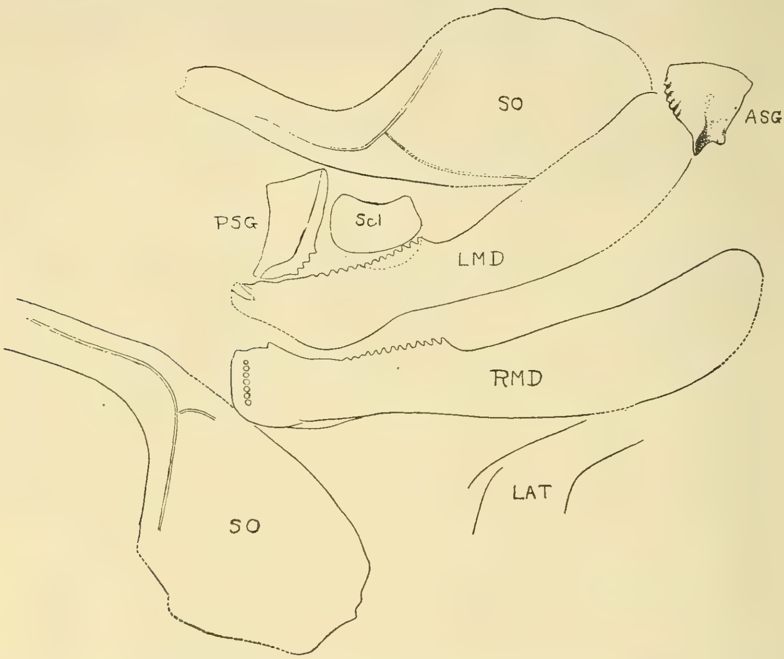

FIG. 25. *Stenognathus mixeri*, n. sp. OUTLINE OF ELEMENTS SHOWN IN TYPE SPECIMEN. × ABOUT $\frac{1}{3}$

The specimen is preserved in counterpart. E 2030. Rhinestreet shale (Portage); Sturgeon Point, on Lake Erie, near Buffalo, N. Y.

ASG, antero-superognathal, in outer view; *LAT*, lateral (or "clavicular"); *LMD*, left mandible, outer view; *PSG*, left postero-superognathal, inner view; *RMD*, right mandible, inner view; *Scl*, segment of the sclerotic ring; *SO*, suborbital—the one above is that of the left side, in outer view; the one below is that of the right side, also in outer view.

being omitted. These plates show in places an ornamentation of very fine tubercles. The specimen is preserved in counterpart, but as the bone was much shattered and partly lost in opening the concretion, it was completely dug out leaving only the impression; from this a

careful cast of each half was prepared, showing the elements in relief. The drawing is made from the cast of the better half of the specimen.

Both *mandibles* (Mnd), are preserved; the left is shown in outer view and the right in inner. Both show well the denticles along the functional margin, and the right shows also the row of symphyseal denticles. These are broken away and represented only by their bases.

Both *antero-superognathals* (ASG) are preserved, although the drawing shows only that of the right side, in outer view. This is one of the most interesting antero-superognathals known, showing the structure of this element in the genus *Stenognathus* better than any other specimen. In the specimen of *Stenognathus gouldi* in the British Museum, figured by Hussakof in 1911,[33] an antero-superognathal is preserved, which is somewhat similar to the present one in size and form; but it is not well enough preserved to show all its characters. The present specimen is therefore of great value, as showing for the first time the complete element in this genus. Its form and peculiarities are described above.

Only the left *postero-superognathal* (PSG) is present, shown in inner view. It is not very well preserved. When collected it had a row of denticles along its cutting margin.

Both *suborbitals* (SO) are present, shown in outer view. They have long, slender processes, and the blades proper are very thin and somewhat shorter posteriorly than in *Dinichthys*. The lateral canals are clearly shown.

Below the pair of mandibles is seen a fragmentary plate (LAT) probably a portion of one of the laterals.

This is the fifth species of *Stenognathus* to be described, and it is easily distinguishable from the others. From *S. gouldi* of the Cleveand shale, and from *S. insignis* of the Conodont bed (see p. 73), it is distinguished at once by the presence of denticles along the cutting margin of the mandible, in these two species the cutting margin being a continuous beveled edge. From *S. dolichocephalus*, which is from the same horizon and locality, it differs by its much larger size and by differences in the form of the various plates. From *S. denticulatus* of the Conodont bed (see p. 71) it is distinguished by its larger size and by the different form of the postero-superognathal.

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[33] Hussakof, L.: Upper Devonian Arthrodira from Ohio in the British Museum (Nat. Hist.). *Geol. Mag.*, [5], viii, 123–128, pl. viii, and text-fig. 6, 1911.

Stenognathus insignis?

E 1957 A small left antero-superognathal which from its size, texture of the bone, and the fact that the tooth is rather weak and might have functioned against just such a beak as that of the *Stenognathus insignis* mandible (fig. 24), we deem it probable that the specimen belonged to that species. The element is small: height, 25 mm., greatest width, 12. The point of the tooth is slightly reflexed upward and outward, and the articulating process is broad, flat and narrowly elliptical in cross-section—not subcircular as in *Dinichthys*.

Conodont bed, (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y.; collected by W. L. Bryant.

Selenosteus sp.

(Text-fig. 26)

This genus is indicated by two imperfect mandibles and several fragmentary armor plates from the Rhinestreet shale (Portage), at Eighteen Mile Creek. So far as we are aware, this is the first record of the occurrence of *Selenosteus* in New York state.

In this genus the head and armor plates are very thin, the dentition feeble, and the remains seem to have been tossed about a good deal and to have become broken or abraded before fossilization. It is one of the rarest of all American Arthrodires.

The mandibles described below are very close to those of *Selenosteus brevis* (Claypole)[34] from the Ohio shale, but are of smaller size. They are not completely enough preserved to allow of a detailed comparison with the mandibles of this species, so that we are not certain whether they represent this or a distinct form. On the other hand, as there are no body plates in our material that can positively be said to belong with these mandibles, there is at present insufficient ground on which to base the description of a new species. It seems probable that when better known this form will turn out to be new.

E 2393 A small left mandible, lacking the anterior, functional portion (fig. 26, *a*). It is represented mostly as an impression

[34] For synonymy of this form see Hussakof, L.: Upper Devonic Arthrodira from Ohio in the British Museum (Nat. Hist.). *Geol. Mag.*, [5], viii, 123–128, pl. viii, 1911.

in shale, except at the posterior extremity where the actual bone is present for a length of 11 mm. In form this mandible agrees well with that of the type species, *Selenosteus brevis,* but is only about half its size. The bone is very thin and bears fine striations similar to

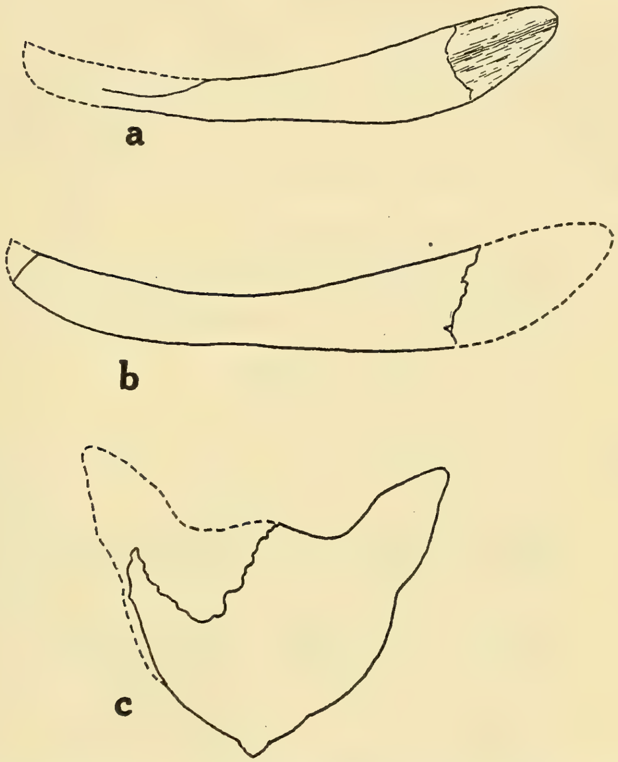

FIG. 26. *Selenosteus* sp. × $1\frac{1}{3}$. RHINESTREET SHALE (PORTAGE); EIGHTEEN MILE CREEK, N. Y.

a, Left mandible.—E 2393. *b,* left mandible.—E 2394. *c,* dorsomedian.—E 2396.

those of the type species. Length, as far as preserved, 43 mm.

Rhinestreet shale (Portage); from Eighteen Mile Creek, near Hamburg, Erie County, N. Y. Collected by W. L. Bryant.

E 2394 A left mandible, somewhat larger than the preceding, lacking the beak and the posterior extremity of the blade (fig. 26,*b*). The greater portion of the functional area is preserved, but no teeth such as are present in the Ohio species are to be seen. The specimen is on shale, and shown in outer view. The bone is thin and finely striated like the preceding specimen.

Formation and locality, same as preceding.

In addition to these mandibles, there are several other remains of a small Arthrodire which perhaps also belong to *Selenosteus*; the reference seems the more probable since they are mostly from the same formation and locality as the mandibles.

E 2395 A small cranial plate. From the thinness of the bone and the occurrence of the specimen in the same formation and at the same locality as the two preceding, we refer it provisionally to *Selenosteus*.

Other data same as preceding.

E 2396 A small dorsomedian shown in outer view, on a piece of shale (fig. 26, *c*). The plate is relatively short and broad, resembling a miniature *Titanichthys* dorsomedian. It bears an ornamentation of small, low tubercles, which are more or less fused on the median portion, but relatively few and scattered on the lateral portion of the plate. Length, 28 mm.; span across anterior angles, 32.

This element probably represents a small species of *Selenosteus*. However, since the left antero-lateral angle is missing, and the front margin appears somewhat frayed, as if broken, we hesitate to base a species upon it, since it perhaps represents a *Coccosteus* dorsomedian, of which the anterior half has been broken away. The resemblance of the element to a *Selenosteus* dorsomedian, depends chiefly on the fact that the front margin is strongly emarginate, the antero-lateral margins being produced into prominent angles. The posterior extremity of the plate is rather thickened and short; if it was drawn out to a point, as in *Coccosteus*, the point has been lost.

Other data same as preceding.

E 2022 Impression of three small ventral plates on a piece of thin shale (Pl. 29, fig. 1). On the reverse of the small slab is a fragment apparently belonging to the same individual, ornamented with fine tubercles. None of these plates shows the entire outline, but there can be no doubt that they belong to a small Arthrodire, probably *Selenosteus*, their size, thinness and texture being suggestive of this form.

Genundewa limestone (Genesee); Eighteen Mile Creek, Erie County, N. Y., collected by W. L. Bryant.

Perissognathus aduncus, n. gen., n. sp.

(Pl. 20, figs. 1, 1a, 1b; Pl. 27, figs. 4, 4a)

E 2397 *Type.*—Functional half of a right mandible, in matrix; shown in outer view. Length, as far as preserved, 78 mm.; height at beak (about 1 cm. restored), 53.

Formation and Locality.—Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Mandible consisting of functional and blade portions (the latter missing in the type specimen). Functional portion a little more than twice as long as the depth at its middle; oral margin a cutting edge, with a pronounced anterior beak; behind this beak a depression formed by the opposing antero-superognathal; and back of this, an obtuse secondary cusp. Symphysis a smooth, almost flat face bent inward at nearly right angles to the outer face of the mandible; its inner margin ending in a row of 7 or 8 teeth, which lie in the plane of this face and are directed obliquely upward at an angle of about 45°; toothed portion of symphysis extending two-thirds down the height of the blade, the symphyseal area below it being a more or less smooth, convex surface. The symphyseal area shows at its upper end, lines of wear which extend parallel to the axis of the beak.

[*Perissos*, extraordinary, wonderful; *gnathos*, jaw. Specific name, *aduncus*, bent in, in allusion to the inrolling of the symphyseal region.]

Remarks.—This remarkable mandible clearly represents an Arthrodire of a new genus. The species is represented in the collection by the type and by a beak of a mandible (E 2165) of about the same size as the

type, which shows a similar symphyseal region and symphyseal teeth. In the type the blade or inserted portion of the mandible is missing, but a small projection of bone on the lower surface near the posterior end of the specimen apparently represents the blade portion and shows that it was present.

The most remarkable character of the mandible is, of course, the symphyseal region, with the 7 symphyseal teeth. These are so clearly shown (Pl. 20, figs. 1a, 1b) as to leave no question as to their number, size, form or direction. The symphyseal region has much resemblance to the denticled symphysis of *Coccosteus*, as shown for the latter in the few specimens in which it is preserved; but the symphyseal teeth in *Perissognathus* being so much larger are far better shown than in any specimen of *Coccosteus.*

There has been considerable discussion of the meaning of the symphyseal denticles in arthrodiran mandibles, and reference may be made to the detailed study of the subject by Hussakof, in 1906.[35] The present mandible throws some light on the problem. In the first place, the upper part of the symphyseal area shows lines of wear parallel to the axis of the beak, produced by the upper tooth. Had the two halves of the lower jaw been united at the symphysis it is inconceivable how an upper dental plate could have played against the symphyseal area on each side, and the two halves of the lower jaw still remain united. Secondly, the direction of the symphyseal teeth, which do not stand at right angles to the inner vertical margin of the symphyseal area but slant upward at an angle of about 45°, shows that these teeth could not have interdigitated; it is a mechanical impossibility for the symphyseal teeth to interlock unless they stood at right angles to the vertical margin of the symphysis.

It may be mentioned that the mandible of *Perissognathus* is also somewhat suggestive of a *Palæomylus* dental plate—at any rate, in its present form, with the hinder blade lacking. It thus serves like several other forms that might be mentioned to connect the Ptyctodontidæ with the Arthrodira, and so lends support to the view set forth by Dollo, in 1907, in his paper, "Les Ptyctodontes sont des Arthrodères."[36]

The following specimen also belongs to *Perissognathus aduncus.* It is from the same formation and locality as the type—Conodont bed, Eighteen Mile Creek—and was collected by W. L. Bryant.

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[35] Studies on the Arthrodira. *Mem. Am. Mus. Nat. Hist.*, ix, 118, 121, 122, *et passim*, 1906.
[36] *Bull. Soc. Belge de Geol.*, xxi, 12 pp., pl. ii.

E 2165 Beak of a left mandible of about the same size as the type (Pl. 27, figs. 4, 4a). It shows well the symphyseal denticles; these are six in number, are directed upward at an angle of 45°, and extend about half way down the symphysis. The area below them is undenticled and outwardly rounded. The bases of the 6 denticles occupy a space of 21 mm.

Machærognathus woodwardi, n. gen., n. sp.

(Pl. 21, figs. 1, 1a, 1b; text-fig. 27)

E 1935 *Type.*—A right mandible, lacking the posterior extremity. Length as far as preserved, 165 mm.; depth at middle of functional area, 30; height of beak, 27.

Formation and Locality.—Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Mandible long and slender, the blade portion apparently much shorter than the functional portion. Oral margin a cutting edge without denticles, worn on the outer face as in *Dinichthys*; with a strong beak directed upward and outward in a straight line and not recurved. Depression between beak and beginning of sectorial edge, broad and shallow. No secondary cusp back of the beak. Functional portion not sharply demarcated from blade portion but gently merging into it. Depth of functional area at its middle, contained about $3\frac{2}{3}$ times in its length. Mandible viewed from above, slightly sigmoidal in section, its front half rather strongly convex outward.

[*Machairos*, knife; *gnathos*, jaw.]

We take pleasure in dedicating this species to Dr. Arthur Smith Woodward, Keeper of the Department of Geology in the British Museum, as an expression of admiration for his work in paleichthyology, as well as a token of appreciation of the many courtesies shown to the authors on their respective study visits to the British Museum.

Remarks.—This mandible differs from that of *Dinichthys* and all other arthrodires by the unusual length of the functional portion as compared with the inserted portion, and by the form of the element as a whole. The blade, or inserted portion, is not completely pre-

served, but even considering the greater portion of it to be missing, or indeed that when complete it was as long as the functional portion, we still have a mandible of very distinctive appearance and unlike that of any other known arthrodire. It represents a dolichocephalic type of arthrodire, comparable in this regard with *Stenognathus*. It resembles this genus also in the absence of the secondary cusp of the mandible. It also has some resemblance to the mandible of *Diplognathus*.

FIG. 27. *Machaerognathus woodwardi*, n. g., n. sp. RIGHT MANDIBLE, LACKING POSTERIOR EXTREMITY. × ½

A, outer view; *B*, inner. Type. E 1935.

Copanognathus crassus, n. gen., n. sp.

(Pl. 22, figs. 2, 3, 4; text-fig. 28)

E 1944 *Type.*—Left mandible. Length, 175 mm.; depth at middle, 55; length of tritoral area, 68.

Formation and Locality.—Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Mandible resembling that of *Dinomylostoma*; with a tritoral area occupying about ⅖ of its length; straight fore-and-aft, not sigmoid; outer face convex, inner almost flat. Functional area not demarcated either on outer or inner face from the blade portion. Tritoral area

widest at about its middle, thence gradually narrowing backward to its point of union with the blade portion; in side view rising gently upward toward the anterior extremity, which is formed into a blunt beak. Depth at middle of mandible contained a little over three times in its total length.

Kopanon, an axe or chopper; *gnathos,* jaw. *Crassus,* dense, in allusion to the dense and robust appearance of the element.]

Remarks.—This mandible has a certain resemblance to both the Dinomylostomid as well as the Ptyctodont type of mandible; and we have hesitated as to which to refer it. But in view of the fact that

FIG. 28. *Copanognathus crassus,* n. g., n. sp. LEFT MANDIBLE, × ½
A, from above; *B*, from inner side. Type. E 1944.

the tritoral area is situated in front, and also because of the form of the element as a whole, and of its microscopic structure which shows typical bone cells, it is more suggestive of an Arthrodiran than a Palæomylid mandible. We are inclined therefore to regard it as an arthrodire and allied to the genus *Dinomylostoma.* From this it is easily distinguishable by its straightness fore-and-aft—*Dinomylostoma* being decidedly sigmoid in cross-section, with the front half of the element convex outward—and by the form of the blade portion, which is relatively deeper near the posterior end. It may also be noted that there is no demarcation between the front and hind halves of the element, as in most species of *Dinomylostoma.*

Dinomylostoma buffaloensis, n. sp.

(Pl. 23, fig. 1; pl. 24, figs. 1, 2, 4, 5; text-fig. 29)

E 1961 *Cotypes.*—(1) A right mandible lacking posterior half of the blade or inserted portion, free from matrix. Length as far as preserved, 106 mm. (Fig. 29; Pl. 24, fig. 1.)

E 1965 (2) A left mandible, lacking only the extreme end of the blade portion. The entire inner face, as well as the greater portion of the outer, are clear of matrix. Length as far as preserved, 136 mm. (Pl. 24, fig. 2.)

Formation and Locality.—Conodont bed (Genesee); Eighteen Mile Creek, near North Evans railroad bridge, Erie County, N. Y. Collected by W. L. Bryant.

Functional portion occupying about $\frac{1}{3}$ the length of the mandible, and not demarcated on outer face from inserted portion. Oral morgin, in outer view, strongly concave, rising rather abruptly posteriorly so as to form an angle at its point of junction with the blade portion, Tritoral area broadest somewhat in front of its middle, its greatest width contained from $1\frac{1}{3}$ to nearly 3 times in the depth of outer face measured at middle of functional portion. Symphysis with three or four denticles, not always clearly shown. Margin immediately behind tritoral area, a compressed cutting edge, about half the length of the tritoral region. Inferior margin in front portion of mandible with a deep groove for attachment, extending forward to where the inferior margin blends into the front margin of the mandible.

Remarks.—This species is represented in the collection by the cotypes and by several other mandibles, one about the size of the cotypes, the others all smaller. Cotype 1, (fig. 29) shows the front half of the mandible in splendid preservation, lacking only the tip of the beak. Cotype 2, is less perfect, but shows almost the entire mandible including the blade or inserted portion. The functional portion in this element agrees closely with that of cotype 1. Among the smaller specimens, E 1966 shows the symphyseal denticles well.

This is the third species of *Dinomylostoma* to be described, the other two being, *Dinomylostoma beecheri* Eastman,[37] from the Portage of Mt. Morris, N. Y.; and *D. eastmani* Hussakof,[38] from the New Albany or

[37] *Amer. Journ. Sci.*, 4 ser., xxi, 137, text- fig. 2, 1906; also a fuller discussion in *Bull. Mus. Comp. Zool.*, L, 23–29, pl. 1, figs. 4, 5; pl. 2, figs. 13, 14; Pls. 4, 5; text-figs. F–H, 1906.
[38] *Bull. Amer. Mus. Nat. Hist.*, xxxii, 245, pl. xlvii, fig. 7 and text-fig. 1 B, 1913.

"Genesee black shale," near Louisville, Ky. From these two, the present species is distinguished by the width of the tritoral area, and by the proportions of the mandible as a whole.

The following specimens seem to belong to this species. They are from the same formation and locality as the types and likewise were collected by W. L. Bryant.

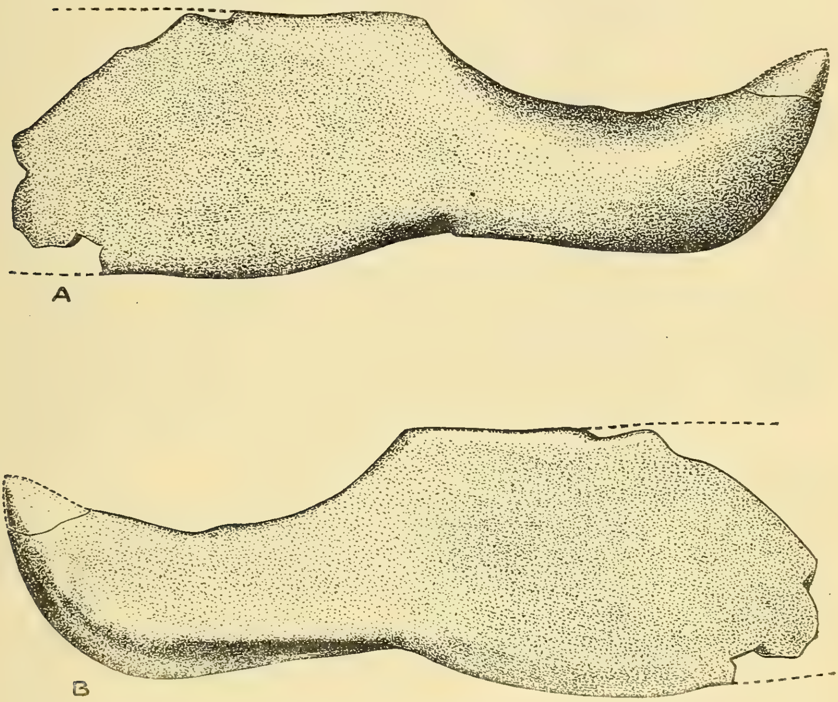

FIG. 29. *Dinomylostoma buffaloensis*, n. sp. RIGHT MANDIBLE, LACKING HINDER PART OF BLADE. NATURAL SIZE

A, outer view; *B*, inner. Cotype No. 1. E 1961.

E 1962 Front half of a small right mandible, which agrees closely with the cotypes. The tritoral area is much worn by use, appearing concave in profile view; and behind the tritoral area there is a short sectorial edge, beveled by wear on the outer face. This sectorial margin is straddled by three or four faint, line-like tritors, 2 or 3 mm. apart, each forming an oblique angle with the cutting margin.

	mm.
Length as far as preserved	62
Length of tritoral margin (concave portion)	40
Depth at middle of tritoral portion	12

E 1963 Front half of a small right mandible of about the same size as the preceding. It shows well the tritoral region and the beak, which is completely preserved. Behind the tritoral excavation there is, as in the preceding specimen, a compressed tritor, beveled on the outer face. It is straddled at intervals of 1 or 2 mm. by line-like tritors.

	mm.
Length of excavated portion of tritor	43
Length of element as far as preserved	61

E 1964 A right mandible of about the same size as the cotypes, lacking the posterior extremity (Pl. 23, fig. 1). It is embedded in matrix, and shown in outer view. It differs somewhat from the cotypes: the excavated portion of the tritoral area is shorter, and the outer margin of the tritoral area is a sharp line instead of being rounded outward. These features, however, are probably only individual variations.

	mm.
Length of element as far as preserved	122
Length of excavated portion of tritoral region	46
Depth at about middle of functional region	20
Greatest width of tritor	6

Behind the excavated portion of the tritoral region there is a short tritor 18 mm. in length.

E 1966 Front half of a small left mandible, showing well the excavated portion of the tritoral region and the beak (Pl. 24, fig. 4). In the symphyseal region there are three or four denticle-like protuberances, rather irregular in outline. The tritoral region behind the excavated portion is not preserved. Total length of element as far as preserved, 75 mm.; depth at about middle of functional region, 16.

E 1967 Front half of a left mandible, smaller than any of the preceding, and rather poorly preserved. The beak is missing, as is also the tritoral region behind the excavated portion of the tritoral margin.

E 1969 Beak of a right mandible about as large as the cotypes.

E 1968 A small left mandible (Pl. 24, fig. 5), which differs from all the preceding in the extreme shortness of the inserted portion, which thins out to a paper edge. This gives the element a peculiar appearance, as if it belonged to a different genus. However, as the inserted portion in mandibles of this species is very thin (as may be seen in the type specimens) and is frequently broken and further thinned by attrition, perhaps facilitated by the chemical disintegration of the superficial layer, it is reasonable to suppose that the extreme shortness and thinness of the blade in the present specimen is due to like causes. This conclusion is supported by the extreme similarity of the functional portion of the element to those described above. The element shows the excavated tritoral region, the beak (which is worn on the outer face), and the front portion of the compressed tritor behind the excavated tritoral portion. In the symphyseal region there are four or five small tritor-like protuberances, one above the other.

The groove for attachment, along the inferior margin of the element, is well shown. Length, 72 mm.; length of excavated portion of functional margin, 60.

E 2507 Front half of a right mandible. The symphyseal denticles six or eight in number, are worn down to their bases and the ridge upon which they stood is polished as by functional wear.

E 2508 Front half of a left mandible. The symphyseal denticles, four or five in number, are succeeded below by a polished ridge.

E 2509 Functional half of a right mandible. The specimen is thin and apparently water-worn.

E 2592 That this species occurs in the West River Shales, is shown by the impression of a large right mandible, lacking only the beak, in a thin limestone layer, collected by Mr. Bryant a few feet above the Genundewa limestone, at Windom, N. Y.

Dinomylostoma sp. [Juvenile]

(Pl. 23, fig. 2)

E 2042 A small left mandible on a piece of shale, shown in outer view. Length, 42 mm. This is the smallest *Dinomylostoma* mandible ever found, and probably represents a juvenile individual.

Rhinestreet shale (Portage); Sturgeon Point, on shore of Lake Erie, N. Y.; collected by Mr. F. K. Mixer.

Dinomylostoma?

(Pl. 27, figs. 5, 6.—*Upper Dental Plates*)

E 1859 and **E 2398** There are two remarkable dental plates in the collection, from the Conodont bed at Eighteen Mile Creek, which differ from all other Arthrodire specimens known to us. They are apparently upper dental plates. From the presence of a large tubercle on the worn surface, (especially well shown in one of the specimens), and the fact that one of the lateral margins falls abruptly away from the wearing surface, somewhat as in a mylostomid dental plate, we are inclined to the view that the two elements are of the same kind, that is, upper dental plates of a mylostomid. And in fact, it is probable that they belong to one of the species of *Dinomylostoma* described above. The reasons for this view are chiefly these: (1) One may expect to find the upper dentition in the formation in which mandibles of the dinomylostomids are found, particularly so as the upper dental plates are compact and would stand an even better chance of preservation than the mandibles. (2) These elements, especially the one shown in Plate 27, figure 5, may be compared in a general way with a mylostomid upper dental plate. (3) Since in the mandible of *Dinomylostoma* the functional margin is excavated, one would expect that the apposing dentition would be convex, and this is the case with the present elements. So that, taken all in all, there is ground for believing that the two elements belong to the upper dentition of *Dinomylostoma*.

The reverse face of both specimens is covered with matrix which cannot be removed, so that the form of this face is unfortunately not to be seen. In the specimen shown in Pl. 27, fig. 6, one of the lateral margins is somewhat excavated, as if facetted for articulating with an adjoining element. This is precisely what one would expect in a *Dinomylostoma* upper dental plate.

Measurements:

E 1859—Length, 46 mm.; greatest height, 18.

E 2398—Length 42 mm.; height, 17

Conodont bed (Genesee); Eighteen Mile Creek, near N. Evans, Erie County, N. Y., collected by W. L. Bryant.

Aspidichthys notabilis Whiteaves

(Pls. 25, 26)

There are several plates in the collection, from the Conodont bed, that bear an ornamentation of large, low tubercles with faint stellations at their bases. These plates apparently belong to a single species. In their ornamentation they resemble most the isolated plates described by Whiteaves in 1892, from the Devonic of Manitoba, and named by him *Aspidichthys notabilis*.[39] The present specimens may, provisionally at least, be referred to the same species. The question, however, arises—Are these plates, and those described by Whiteaves, properly referable to the genus *Aspidichthys?* Whiteaves placed them in this genus with a question mark.

At the present time, three American Arthrodires are known that have an ornamentation of large tubercles, namely: *Trachosteus*, *Glyptaspis* and *Aspidichthys*. The specimens in hand must therefore be compared with these three genera.

As far as the genus *Trachosteus* is concerned, we have examined the type, which is preserved in the American Museum. The ornamentation of this genus consists of large tubercles somewhat comparable in size with those of the Conodont plates. But these tubercles are higher and more pointed, being in fact denticles rather than tubercles, and with very many more radiations at their bases and in the spaces between contiguous tubercles. In the Conodont bed specimens the

[39] Whiteaves, J. F.: The fossils of the Devonian rocks of the islands, shores or immediate vicinity of Lakes Manitoba and Winnipegosis. *Contribs. to Can. Palæon.*, I, 354, pl. xlvii, 1892.

tubercles are all low, smooth and rounded, and may be described almost in the words applied by Whiteaves to those of the Manitoba specimens:

> The surface markings . . . consist of numerous small, smooth and rounded tubercles, which are unequal in size and irregular in their distribution, though the largest average 2 mm. in diameter at the base, and from 2 to 5 mm. in their distance apart at the summits. The greater part of the beveled or outer margin is smooth to the naked eye, but around its outer limits there are indications of short and irregular radiating grooves and ridges.[40]

It appears therefore, even on the evidence of the ornamentation alone, that the Conodont specimens do not belong to *Trachosteus*. There is, also, the further evidence from the shape of the plates. In *Trachosteus* the antero-ventrolateral is short and broad, and very different in form from the specimens in hand.

We have also compared the specimens with the genus *Glyptaspis*, using for comparison the type specimens which are in the Newberry collection in the American Museum. In *Glyptaspis* the antero-ventrolateral is fortunately known, so that we are able to compare plates of the same kind. But the denticles of the two forms are very different. In *Glyptaspis* they have a tendency to run into lines, and this is particularly well shown on the antero-ventrolateral. In the Conodont specimen of this plate, on the other hand, the denticles never run into lines, but always remain discrete. Furthermore, in *Glyptaspis* the antero-ventrolateral has a broad, smooth border on its outer or ornamented face, whereas in the Conodont antero-ventrolateral there is no such border, the tubercles running clear to the margin on one side, and on the other terminating in an irregularly delimited smooth area, not sharply defined from the ornamented portion. It seems, therefore, that the Conodont specimens cannot be placed in the genus *Glyptaspis*.

There then remains only the genus *Aspidichthys* of forms with tubercles comparable with those of the present specimens. In *Aspidichthys clavatus* Newberry, the tubercles are much larger than in either the present specimens or the Manitoban plates. However, their height, roundness, distribution, and the occurrence of smaller denticles amongst the larger ones, is in *Aspidichthys* very much as in the specimens in hand. The mere difference in size of the denticles would not exclude the present specimens from that genus, since it is known

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[40] Loc. cit., p. 355.

that there is considerable difference in the size and character of the tubercles among the species of one genus; in fact, one species may have tubercles and another not, as is seen in the genus *Dinichthys*. It therefore seems proper to refer the present specimens to *Aspidichthys*, merely extending the definition of this genus so as to include forms with denticles of the same kind, but of somewhat smaller size.

The following specimens are all from the Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, New York. Collected by W. L. Bryant.

E 1970 Right antero-ventrolateral lacking anterior portion (Pl. 25). The posterior tip is restored from a squeeze taken from the impression in the matrix. The plate as far as preserved, is 22 cm. in length, and 11 cm. in maximum width. The ornamentation consists of large, smooth, rounded tubercles, somewhat unequal in size and some of them slightly stellate at the base; a portion of the inner border of the plate is smooth, without denticles. The plate is practically uniform in thickness throughout and the under side is almost smooth, showing no striæ.

E 1971 An imperfect plate, probably a ventral, with its impression in matrix. Its ornamentation resembles that of the preceding specimen, except that in places the tubercles are somewhat more crowded. (Pl. 26, fig. 2.)

E 1972 Fragmentary plate.

E 2399 Impression of the front half of an antero-ventromedian and a plaster cast made from it (Pl. 26, fig. 1). This plate differs from all other antero-ventromedians yet described. Its characters are clearly brought out in the illustration. Along the front margin as well as on either side it has a broad flange for overlap by the other plates of the plastron. From the fact that it narrows but little posteriorly, it would appear to have been squared off more or less posteriorly, instead of ending in an acute point, as is the case in the species of *Dinichthys* in which the antero-ventromedian is a distinct plate. On the visceral surface the anterior margin is strengthened by a low ridge, and, running backward from this, in the median line, there is another low, rounded ridge very much as in *Dinichthys*,

This specimen was collected by Prof. C. J. Sarle.

E 1949 Two fragments, ornamented with large tubercles, apparently referable to this species.

Arthrodira, Gen. et sp. indet.

In addition to the Arthrodiran remains described in the preceding pages, there are a number of plates in the collection which apparently also belong to Arthrodires, but which are too imperfect for reference to particular genera. These are briefly described below, and the more interesting ones are figured. No doubt perfect specimens of most of them will in time be found and thus enable one to answer the tantalizing questions which they call forth.

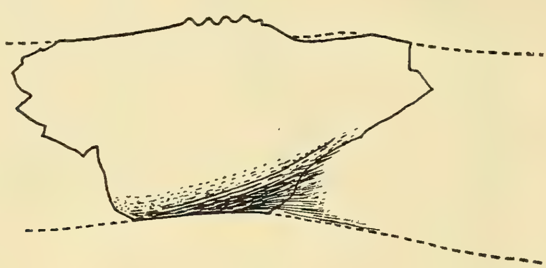

FIG. 30. FRAGMENT OF A LEFT MANDIBLE OF AN INDETERMINATE ARTHRODIRE; OUTER VIEW. NAT. SIZE. E 1945

a. Mandibles

There are three imperfect mandibles in the collection, representing one, and perhaps two, new genera of Arthrodires, but which are too imperfect to be named. For the present it seems advisable merely to illustrate and call attention to them. It is to be hoped that better material will soon be discovered which will make possible the defining of these interesting forms.

Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

E 1945 Fragment of a left mandible, consisting of the posterior half of the functional portion and the beginning of the blade portion (text-fig. 30). The oral margin is a cutting edge, rather blunt through use. At its posterior end are five low denticles, occupying a space of 12 mm. Behind the

denticles the margin slopes down to meet the inserted portion of the mandible, producing a conspicuous "shoulder" in the region of these denticles.

E 1945a Fragment of a right mandible of about the same size, and showing about as much, as the preceding except that the cutting margin and the denticles are not so well preserved.

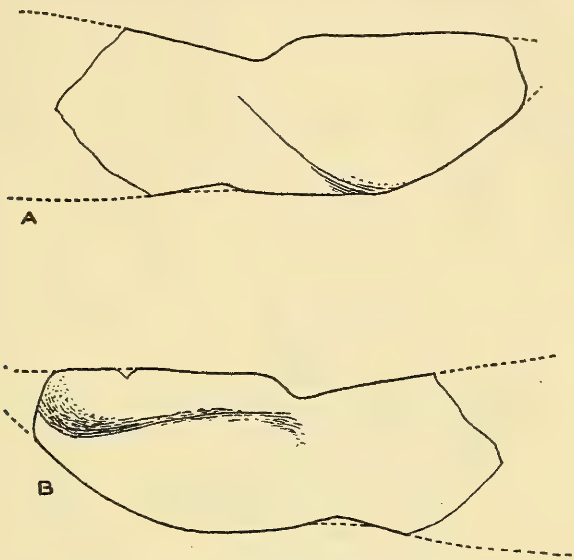

FIG. 31. IMPERFECT MANDIBLE OF AN INDETERMINATE ARTHRODIRE, PROBABLY A NEW GENUS. NAT. SIZE

A, outer view; *B*, inner. E 1934.

E 1934 Imperfect small mandible, lacking anterior extremity and the posterior part of the blade portion (fig. 31). The blade portion is demarcated from the functional portion, on the outer face, by a gradual change in level. The functional margin is a cutting edge with a "shoulder" at the point where it joins the inserted portion. The cutting edge is restored in the present condition of the specimen but was intact when the specimen was collected.

This mandable apparently represents a different genus from the two preceding. No doubt a perfect specimen

of it will some day be discovered, and we may defer naming it until then. Its closest affinities seem to be with the genus *Hussakofia.*

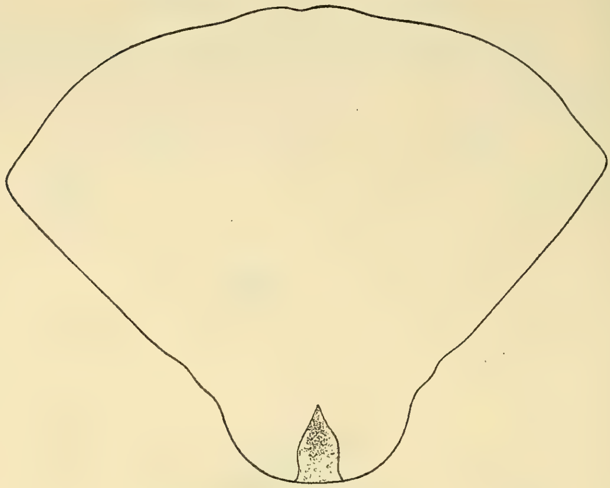

FIG. 32. RESTORED OUTLINE OF DORSOMEDIAN PLATE, × ABOUT $\frac{1}{3}$. E 1892

b. Antero-superognathal

(Pl. 27, fig. 7)

E 1946 A small left antero-superognathal which differs from all other specimens of this element known to us. It consists of a single small but powerful cusp. There is no secondary cusp. The element is well shown in the figure in Plate 27. There is no doubt that it belongs to an Arthrodire, but we are unable definitely to assign it to *Dinichthys* or to any other genus.

Conodont bed; Eighteen Mile Creek, N. Y. Collected by W. L. Bryant.

c. Head and Body Plates

E 1867 Portion of a small lateral, or so-called "clavicular," plate.

Onondaga limestone (Mid Devonic); Cement Quarry, Buffalo, N. Y. Collected by W. L. Bryant.

E 1868 Fragmentary plate. Formation and locality same as preceding. W. L. Bryant, collector.

E 1892 One half of a dorsomedian plate, fractured along the median keel. The plate is massive and much waterworn, and probably belongs to an undescribed arthrodire. The half preserved measures 17.5 cm. in length and 12.5 cm. in greatest width. The keel apparently did not extend beyond the posterior extremity of the shield, at which point it is massive and deep (4 cm.), and apparently excavated. Figure 32 shows the restored outline, based on the half preserved.

Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by Prof. P. F. Piper.

E 2400 Impression in rock, with a fragment of the bone, of a small plate which tapers to a point. It is about 6 cm. long and 3.5 cm. at its widest part. It was keeled in the middle line, and suggests somewhat the dorsomedian of *Coccosteus*. The bone was very thin and its external surface seems to have been ornamented with broad lines running obliquely across the plate. It is impossible, of course, to determine the systematic position of this plate; it will probably turn out to be a new genus.

Conodont bed (Genesee), Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

E 1988 A small element tapering to a point; perhaps a lateral plate (Pl. 20, fig. 2).

Other data same as preceding.

E 2007 A small fragmentary plate apparently belonging to the orbital region of a cranial shield.

Other data same as preceding.

E 2043 A very small juvenile lateral, or "clavicular," of a Dinichthyid, in matrix; outer view. (Plate 28, figure 2.)

Rhinestreet shale (Portage); Sturgeon Point, N. Y. Collected by W. L. Bryant.

Genus **Acanthaspis** Newberry

This genus is known by isolated plates, usually with a spine attached to one side. They occur in the Devonic of both Europe and America—in America typically in the Mid Devonic limestone of Ohio, New York and Wisconsin.

There has been considerable discussion as to the affinities of these plates; but from the researches of Traquair,[41] and Smith Woodward,[42]

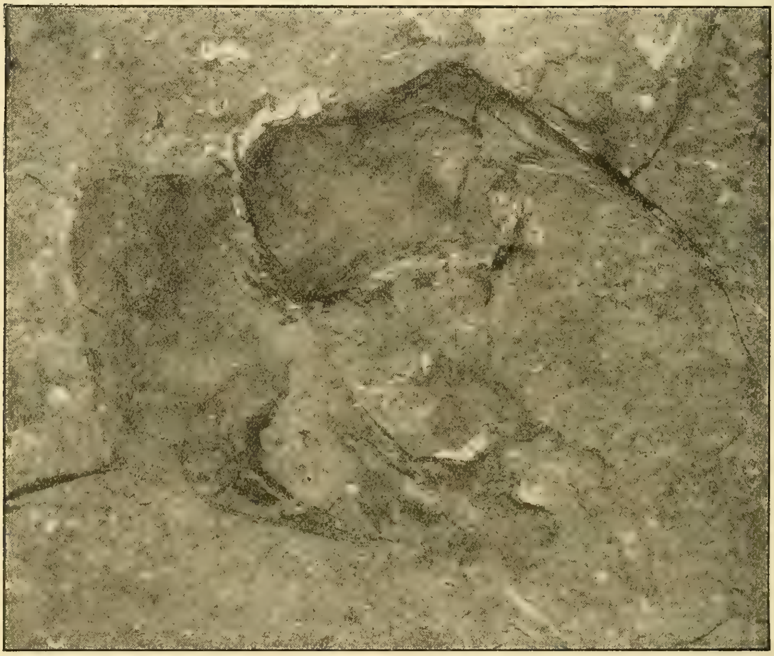

FIG. 33. *Acanthaspis armata* NEWBERRY. A PAIR OF ANTERO-VENTROLATERALS, IN INNER VIEW. × ½. E 1857

it appears that they are the antero-ventrolaterals of a ventral armor somewhat similar to that of *Phlyctænaspis*, and hence that they represent an Arthrodire.

Recently Eastman[43] has advocated the view that they belong with

[41] The Devonian fish fauna of Spitzbergen. *Ann. Mag. Nat. Hist.*, 1, 15, pls. i–iii, 1891.
[42] Further contribution to the knowledge of the Devonian fish fauna of Canada. *Geol. Magazine*, [3], ix, 481–485, pl. xiii, 1892.
On the Devonian fishes of Campbelltown and Scaumenac Bay in Canada, No. 2. *Geol. Magazine*, [3], x, 145–149, 1893.
[43] Devonian fishes of Iowa. *Ann. Report Iowa Geol. Survey*, xviii, 144, 1908.

the Ptyctodont tritors which are almost always found in the same rocks. This opinion, even if substantiated by the finding of *Acanthaspis* plates and Ptyctodont tritors in association, would not in our view militate against referring *Acanthaspis* to the Arthrodira, but be another link in the chain of evidence tending to prove that the Ptyctodonts are themselves Arthrodires, though with a specialized dentition.

In the Buffalo Museum there are two specimens of *Acanthaspis* that add somewhat to our knowledge of this form. One consists of two ventral plates, the right and left of one individual, on a block of limestone. Another is a plate with an attached spine in which the cross-

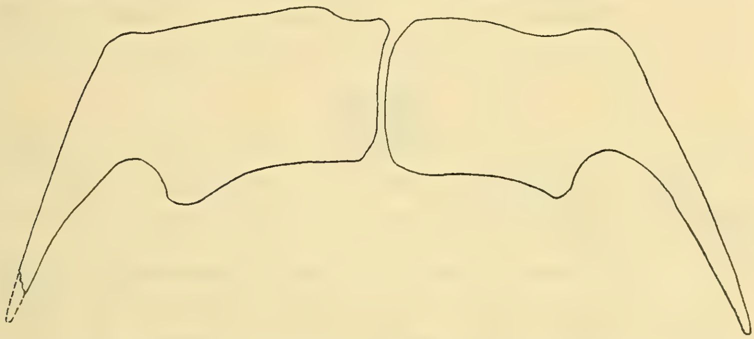

FIG. 34. *Acanthaspis armata* NEWBERRY. RESTORED OUTLINE OF SPECIMEN SHOWN IN FIGURE 33

section of the spine is clearly shown. This is elliptical, and proves that the spine was not as compressed as might be thought from its attachment to so thin a plate.

Acanthaspis armata Newberry

E 1857 Block of limestone bearing right and left antero-ventrolaterals with their attached spines. (Text-figs. 33, 34.) There is also a fragmentary indeterminable plate on the same block. The specimens are shown in inner view; the suture between each plate and its attached spine cannot be made out. In one spot an impression shows the ornamentation of the outer face; this consists of the characteristic ornamentation of this species.

A restored outline showing the plates in natural relation to each other is given in figure 34.

Onondaga limestone (Mid Devonic); Williamsville, N. Y. Collected by Dr. Richard Rathbun.

E 2401 A rectangular plate with attached spine, on a piece of limestone; shown in outer view. The plate is mostly weathered away, but in places where it is preserved, it is seen to have an ornamentation of dots running into lines which are more or less parallel to one another and to the outer margin of the plate. An interesting feature of the specimen is the fact that the core of matrix of the proximal half of the spine seems to preserve the thickness of the spine in life (fig. 35). So far as we are aware, this is

FIG. 35. *Acanthaspis armata* Newberry. CROSS-SECTION OF SPINE
The shaded area is the central cavity infiltrated with matrix; natural size. E 2401

the first specimen of *Acanthaspis* to be found which clearly shows the section of the spine. This is elliptical and rather thicker than is generally supposed, the shorter diameter of the section being two-thirds the longer.

The specimen agrees pretty closely with specimens of *Acanthaspis* from the Delaware limestone of Ohio, and although the ornamentation of the plate is rather more linear than is usual in these elements, still it seems to us referable to the typical species, *Acanthaspis armata*.

Onondaga limestone; Leroy, N. Y. Collected and presented by Prof. C. J. Sarle.

Acanthaspis sp.

E 2013 A detached spine (Pl. 28, fig. 4). It is of the usual form of the distal half of the spines of *Acanthaspis armata*, and somewhat triangular in cross-section. It bears a few scattered tubercles, and on the inner surface, parallel incised lines.

Conodont bed (Lower Genesee); Eighteen Mile Creek, North Evans, near Buffalo, N. Y. Collected by W. L. Bryant.

E 2024 Antero-ventrolateral lacking the lateral spine, shown in inner view (Pl. 30, fig. 2).

Genundewa limestone (Genesee); Eighteen Mile Creek, North Evans, near Buffalo, N. Y. Collected by W. L. Bryant.

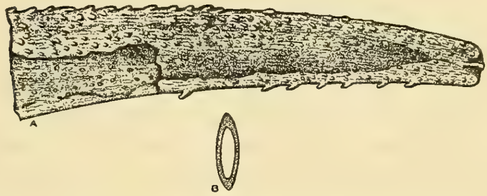

FIG. 36. *Acanthaspis* sp. DISTAL HALF OF A SPINE, × 2

A, side view; *B*, cross-section at about middle of spine. E 2029.

E 2029 Distal half of a small spine (fig. 36), apparently a lateral appendage of *Acanthaspis*, on a piece of shale. The ornamentation consists of tubercles, some of them elongated or tear-shaped and pointing downward. Length as far as preserved, 32 mm.; greatest width, 6; width near apex, 3.

Rhinestreet shale (Portage); Shore of Lake Erie, near Sturgeon Point. Collected by Dr. H. U. Williams.

INCERTÆ SEDIS

The genera and species following are known only by isolated armor plates whose relationships are at present unknown. Some of them—for instance, *Holonema*—seem to be Arthrodira, but concerning the others no positive statement can at present be made.

Eczematolepis fragilis (Newberry)[44]

(Pl. 29, fig. 2; Pl. 30, fig. 1)

This species has already been recorded from the Onondaga of western New York.[45] It is interesting to note that it, or a very closely

[44] However undesirous we may be of using a name like *Eczematolepis*, the rule of priority leaves us no choice in the matter, since the earlier and more euphonious name, *Acantholepis*, is clearly preoccupied. See O. P. Hay: Bibl. and Catal. of the Fos. Vert. N. Amer., p. 332. *Bull.* 179, *U. S. Geol. Survey, 1902.*

[45] Eastman, C. R.: Devonic fishes of the N. Y. formations, p. 79. *N. Y. State Mus., Mem.* 10, 1907.

related form, occurs also in the Conodont bed at Eighteen Mile Creek, as evidenced by a specimen mentioned below.

E 1856 Fragmentary plate in matrix, showing the characteristic tuberculation of this species. (Pl. 29. fig. 2.)

Onondaga limestone (Mid. Devonic); Williamsville, N. Y. Collected by Dr. Richard Rathbun.

E 2014 Fragmentary plate, in matrix; shown in outer view (Pl. 30, fig. 1). It bears fine tuberculations and is on the whole comparable with the type species, *E. fragilis*.

Conodont bed (Lower Genesee); Eighteen Mile Creek, North Evans, near Buffalo, N. Y. Collected by W. L. Bryant.

Eczematolepis telleri (Eastman)

This species was described and illustrated in detail in a paper by Edgar E. Teller published in 1906.[46] Specimens are there figured showing a broad spine-like plate to which a second plate is attached, the two together suggesting somewhat the arrangement of an *Acanthaspis* plate and its spine. But there seems no ground for separating this form, from *Eczematolepis* as a distinct genus, *Phlyctænacanthus*, as was done by Eastman.[47] In fact these specimens from Wisconsin are so like those of *E. fragilis*, the type species, from Ohio, that there is barely ground even for specific separation from the latter form.

These plates have generally been found associated with dental elements of *Palæomylus*, and it is not improbable that they belong with this type of dentition.

E 1878 Plate in matrix, shown in outer view.

Hamilton (Mid. Devonic); Milwaukee, Wis. Collected and presented by Mr. Edgar E. Teller.

Holonema abbreviatum (Eastman)

(Pl. 31)

Glyptaspis abbreviata EASTMAN, New York State Mus., Mem. 10, p. 147, pl. 13. 1907.

In 1907 Eastman described a ventral plate from the basal strata of the Portage, which was ornamented with raised lines here and

[46] *Bull. Wisconsin Nat. Hist. Soc.*, iv, 192, pl. iv.
[47] *Amer. Naturalist*, xxxii, 551, fig. 49. 1898.

there broken up into rows of dots. He referred it to the genus *Glyptaspis* of Newberry, under the specific name *abbreviata*.

Apart from this species *Glyptaspis* is known only by the type species *G. verrucosa* Newberry. A cast of Eastman's specimen is in the American Museum and we have compared it carefully with Newberry's types of *G. verrucosa* which are also in the American Museum; and we have come to the conclusion that the *abbreviata* plate does not belong in the genus *Glyptaspis*. G. *verrucosa* is ornamented with large tubercles, closely rounded, and arranged in rows, whereas *G. abbreviata* is ornamented with thread-like lines and dots which are much finer than in the former species. Moreover, the *abbreviatum* plate seems too short and broad to belong with such plates as those named *G. verrucosa*; they indicate an animal of very different proportions. The type of *G. abbreviata* belongs properly in the genus *Holonema* of Newberry, in which it may stand as a distinct species distinguished from the other species known, by the width of the spaces separating the lines of ornamentation and by the breaking up of these lines into discrete dots, even more so than in *Holonema rugosum*.

The species was previously known from the Portage of western New York and from the Genesee of Kentucky-Indiana. Three specimens in the Buffalo Museum establish its presence in the Conodont bed (basal Genesee), and in the limestone layer above the Genundewa, and thus prove it to range in western New York from the base of the Genesee up into at least the lower portion of the Portage.

E 2009 Imperfect plate, ornamented with nearly straight, parallel beaded lines.

Conodont bed (Lower Genesee); Eighteen Mile Creek, North Evans, near Buffalo, N. Y. Collected by W. L. Bryant.

E 2444 Lateral or ventral plate with the characteristic ornamentation of this species, with straight margins on three sides. It measures 11.5 by 9 cm.

Other data same as preceding.

E 2025 A flat, subrectangular plate apparently belonging to the ventral armor (Pl. 31). It is almost complete, and its ornamentation agrees closely with that of the type specimen of *Glyptaspis abbreviata* figured by Eastman. At the upper and lower margins of the plate, the ornamenta-

tion consists almost entirely of raised dots; these coalesce more and more toward the center of the plate tending to fuse into irregular and tortuous thread-lines trending in a general way toward the center of the plate. The plate is very thin, not more than one-eighth of an inch in thickness. Length 110 mm.; greatest width 65.

From the limestone band in the West River shale (Genesee), a few feet above the Genundewa Limestone, Eighteen Mile Creek, North Evans, near Buffalo, N. Y. Collected by W. L. Bryant.

Holonema rugosum (Claypole)

(Pl. 32, fig. 1)

E 2513 Cast of a plate 12 by 13 cm. It is of great interest for showing on the outer, ornamented face several tooth marks apparently inflicted by a contemporary animal, probably a dinichthyid.

Original in private collection of Mr. Edgar E. Teller of Buffalo, N. Y., to whom we are indebted for the privilege of taking casts not only of this but of a number of other specimens.

Hydraulic cement rocks (Mid. Devonic); Milwaukee, Wis.

The fragmentary plates figured by C. K. Swartz in his recent work on the middle and upper Devonian of Maryland, under the name *Glyptaspis eastmani* (*Maryland Geol. Surv.: Middle and Upper Devonian*, p. 700, pl. 73, figs. 1–3, 1913), seem to us to belong in this genus and even perhaps in this species, which apparently had a wide geographical distribution.

Holonema sp.

(Pl. 33, fig. 2)

E 2512 Cast of a fragmentary plate remarkable for its thickness (1 cm.). It is apparently a fragment of a much larger plate. It is ornamented on the outer face with thread-like lines which anastomose in places into a reticulated network, on the whole more suggestive of *Holonema* than of any other genus.

Original in collection of Mr. Edgar E. Teller.
Hydraulic cement rocks (Mid. Devonic); Milwaukee, Wisconsin.

Oëstophorus lilleyi (Newberry)

(Pl. 33, fig. 1)

Sphenophorus lilleyi NEWBERRY, Paleozoic Fishes N. Amer., p. 92, 1889.

In his *Paleozoic Fishes of North America*, Newberry described (p. 92, Pl. xx, fig. 15) an imperfect plate from the Chemung of Pennsylvania, remarkable for bearing an ornamentation of arrowhead-shaped tubercles. He regarded it as a clavicle probably belonging to a crossopterygian. Since that time, other fragmentary plates with a similar ornamentation have been found, notably in the Hamilton of Wisconsin, but none perfect enough to throw light on their taxonomic position. And it is true now as was said by Newberry that, "until some other portions of the fish shall be discovered, it will be impossible to speak positively in regard to its relations."

In the collection of Mr. Edgar E. Teller of Buffalo, there is one of these plates, from the Hamilton of Milwaukee, which seems to bear an attached spine as in *Acanthaspis*, but as neither the plate nor the spine are very perfect, we hesitate to draw any conclusion from the specimen as to the relationship of the genus.

Fragmentary plates bearing the same style of ornamentation, and probably referable to the same species, occur in the Conodont bed at Eighteen Mile Creek. One such plate in the Buffalo Museum is illustrated in Plate 33, figure 1.

E 1898 Fragmentary plate showing the characteristic arrowhead-like ornamentation, 8 by 5 cm.
Hamilton limestone (Mid. Devonic); Milwaukee, Wis. Collected by Mr. Edgar E. Teller.

E 2012 Small fragmentary plate showing the arrowhead-like ornamentation characteristic of this genus (Pl. 33, fig. 1).
Conodont bed, (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Dermal Plates—Gen. and sp. indet.

(Text-fig. 37)

Two fragments of plates in the collection, found in the Conodont bed, at Eighteen Mile Creek, differ from all other ornamented plates hitherto described and probably represent a new genus. They are flat, 2 to 4 mm. in thickness, with one face perfectly smooth, and the other ornamented with parallel, low, rounded ridges which gradually diminish in diameter toward one side of the plate. Along one edge, which is perfect, the smooth face of the plate (in both specimens) is beveled to a knife edge, the beveled margin being 4 mm. in width. The ornamented face, on the other hand, shows no beveling, the ridges continuing clear up to the edge. The ridges make an angle of about 60° with this natural edge.

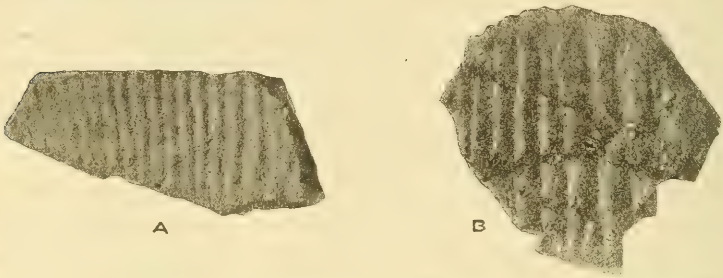

FIG. 37. FRAGMENTS REPRESENTING AN UNDISCOVERED GENUS, PROBABLY ARTHRODIRAN. NATURAL SIZE

A, fragment with narrow ridges; E 2440. B, fragment with coarser ridges E 2439.

These fragments clearly indicate a form different from any hitherto described. They may be compared only with *Holonema* plates, although in the latter genus the ridges are very much finer and usually broken in places into dots. The fragments appear so peculiar that we have even doubted whether they belong to fishes, but micro-sections of them clearly show bone cells.

It would, of course, be premature to name this form until at least one complete plate is found.

E 2439 A fragment 3 cm. in length (fig. 37B), bearing 8 low ridges on the ornamented face. The broadest ridge is 4 mm. wide, the narrowest about 2.

Conodont bed, (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

E 2440 A fragment similar to the preceding, 3.5 cm. in length (fig. 37 A), with narrower ridges and the spaces between them somewhat wider than in the preceding (one-third to one-half the width of the ridges).

Formation and locality same as preceding.

CYCLIÆ

Palæospondylus gunni Traquair

E 2441 A specimen showing the head and vertebral column in great perfection, but lacking detail in caudal fin. On the same slab is a poor specimen of *Mesacanthus peachi* (Egerton).

Middle Old Red Sandstone; Achanarras, Caithness, Scotland.

PTYCTODONTIDÆ

The family Ptyctodontidæ is known only by dental plates and isolated tritors. Associated with them are plates of various genera—e. g., *Acanthaspis*, *Eczematolepis*—and the suggestion has been made that these are the body-plates of the fishes to which these dental plates belonged. However, conclusive proof of this is not yet at hand, and for the time being we must continue to refer to the body-plates and the dental elements under separate names.

There are three genera of the Ptyctodontidæ: (1) *Ptyctodus*, with the entire, or almost entire, oral margin formed into a grinding tritor; (2) *Rhynchodus*, with oral margin a cutting blade; (3) *Palæomylus*, with a grinding tritor, but the element is much larger and differently formed from that of *Ptyctodus*. Of these genera, the first and third are confined to the Devonic, while the second ranges into the Carbonic.

The genus *Rhamphodus*, described by Jaekel from the Eifel Devonic is apparently identical with *Rhynchodus*, as was pointed out by Eastman.[48]

In addition to these there is a new form described as a new genus on a subsequent page of this catalog.

[48] "Devonian fishes of Iowa." *Ann. Rept. Iowa Geol. Survey*, xviii, 127–129, 1908.

Genus **Ptyctodus** Pander

The Conodont Bed at Eighteen Mile Creek has yielded a wonderful series of ptyctodont dental plates and tritors,—without question the largest number of perfect specimens ever obtained from any formation, or, in fact, from all other formations put together. Three species are represented here—*Ptyctodus calceolus*, the typical and most widely distributed species, which ranges through the Middle and Upper Devonic; *P. compressus*, a species hitherto known only by a few imperfect elements from the Upper Devonic of Iowa; and *P. howlandi*, a splendid, large species described here for the first time.

Ptycotdus calceolus Newberry & Worthen

(Pl. 34; Pl. 36, figs. 1, 2, 10; Pl. 37, fig. 9)

This species is represented in the Buffalo Museum by two series of dental plates and tritors—one from the Hamilton of Milwaukee, and a second and larger series from the Conodont bed at Eighteen Mile Creek.

a. Specimens from the Hamilton limestone (Mid. Devonic); Milwaukee, Wis. Collected and donated by Mr. Edgar E. Teller.

E 1884 Right lower dental plate (Pl. 34, figs. 1 and 3).
This specimen is of unusual size, being nearly 6 cm. in length. It apparently belonged to an old individual; the triturating surface is worn down below the level of the lateral faces of the plate.

E 1885 An isolated tritor.

E 1886 An isolated tritor.

E 1887 An isolated tritor.

E 1888 Left upper dental plate.

E 1889 Imperfect right lower dental plate.

b. Specimens from the Conodont Bed (Lower Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Owing to the refractory character of the Conodont bed limestone, it is very difficult to extricate the tritors from the matrix; the specimens are usually broken and in most instances the thin side walls are lost. These specimens agree well with those from the Hamilton of Milwaukee, from which they are specifically indistinguishable.

E 1913 Three small upper dental plates in splendid preservation (Pl. 36, figs. 1, 2; Pl. 37, fig. 9). They show the low beak, the entire tritor and the bevelled cutting margin. They are relatively shorter and broader than the upper dental plates of *P. compressus*, and the region back of the tritor falls away uniformly all around; i.e., the inner and outer faces do not meet in a sharp edge behind the tritor as in *P. compressus*. The smallest of the three elements is 22 mm. in length (including 1 mm. allowed for missing posterior extremity). The next larger element is 37 mm. in length; height of beak (its lower margin is completely preserved), 10 mm. (including 1 mm. allowed for missing tip); max. width of tritor, 4.5 mm. The tritor shows clearly the rows of punctæ. The largest element is 40 mm. in length; height of beak, 9; max. width of tritor 4. The tritor is much worn and the rows of punctæ while present are scarcely seen.

E 2409 Two imperfect tritors of dental plates much larger than the preceding. They clearly belong to *P. calceolus* as shown by their width, which is much greater than in *P. compressus*, and, in one of them at least, the absence of the ridge behind the tritor. The larger of the two specimens shows the rows of punctæ, although they are obliterated in places through wear. In the other specimen—the posterior half of a tritor—the punctæ have been almost entirely obliterated.

E 2431 A left upper dental plate shown, natural size, in Plate 36, figure 10. The beak is rounded off, and just behind it is a bevelled area produced by the play against it of the left lower beak.

Ptyctodus compresses Eastman

(Pl. 36, figs. 3–9, 11, 12; Pl. 37, figs. 1–8, 10–13)

This species is represented in the collection by over three dozen specimens, collected at various times by Mr. Bryant, from the Conodont bed, at Eighteen Mile Creek. It is the finest series of ptyctodont plates of one species ever assembled, some of the specimens being exquisitely preserved and showing all the details of structure.

E 1911 A rather large, perfect right lower dental plate, (Pl. 37, fig. 12) partly embedded in limestone; in inner view. Length 46 mm.; height at beak, 14; max. width of tritor, 6. The rows of punctæ are well shown, as is also the compressed edge back of the tritor.

E 1912 A large, much worn, left lower dental plate (Pl. 36, fig. 9). This is the largest specimen of this species ever found. It is 68 mm. in length (including in this 5 mm. allowed for missing posterior extremity). Max. width of tritor, 8 mm. The tritor is much worn, posteriorly excavated so that the region back of the tritor appears to rise upward. The linear arrangment of the punctæ is entirely obliterated.

E 1914 Five right lower dental plates. One, in inner view (Pl. 37, fig. 6), is 43 mm. in length (including in this 3 mm. allowed for missing posterior extremity). It is one of the most perfect dental plates ever found. It shows well the spiniferous process below the symphyseal region. The beak is pointed, and the cutting edge following it, as well as the tritor, are well preserved. It shows the inferior margin of the inner side, which is very rarely preserved. The others are shown in Plate 36, figures 3, 8, 12; Plate 37, fig. 4.

E 1914–A Two left lower dental plates (Pl. 37, figs. 3 and 5), one of them embedded with its lower margin in matrix.

E 1916 Two rather small right upper dental plates. We figure one of these in Plate 36, figure 5.

E 1917 Three left upper dental plates, one of them in matrix (Pl. 36, fig. 6; Pl. 37, fig. 2).

E 1921 A very small lower dental plate. Despite its small size, it shows all the characters of the species—beak, cutting margin, narrow tritor and compressed edge behind tritor. Total length, 15 mm.

E 1922–3 (1) A right lower dental plate, lacking only the tip of the beak; (2) the front half of a left dental plate.

E 1924 Imperfect left lower dental plate.

E 1925 Minute right lower dental plate.

E 1931 Imperfect lower dental plate, in limestone.

E 2404 A right lower dental plate showing well-preserved oral margin (Pl. 37, fig. 11).

E 2406 Two rather small upper dental plates. One of them, of the right side, is figured (Pl. 37, fig. 1).

E 2407 A rather large, worn lower dental plate, lacking the hinder third.

E 2408 Two left lower dental plates (Pl. 37, figs. 10 and 13). The larger and better preserved one of the two (fig. 10), is the next largest element to No. E 1912 in the collection. It shows well the spiniferous process, below the symphyseal region both in outer and inner view. Length 58 mm. (including 3 mm. allowed for missing posterior extremity). Height at beak, 15; max. width of tritor, 5. The tritor shows the rows of punctæ, although they are a good deal worn and in the front half of the tritor are completely obliterated.

E 2410 Right lower dental plate (Pl. 36, fig. 4). The tritor is very narrow and the cutting edge in front of it is but little developed. The beak is sharply pointed. The ridge behind the tritor is well shown.

E 2411 Eight small dental plates, three of them among the smallest ever collected. The smallest is only 11 mm. in length; another, lacking the posterior end, is 14 mm. in length, when complete must have been about 18 mm.

E 2432 Four right lower dental plates ranging from 21 to 43 mm. in length. Two of them (Pl. 36, fig. 7; Pl. 37, fig. 8), show the inner face better preserved than in any other specimen. This is very deep, giving the plate in inner view a somewhat semilunar appearance.

E 2433 A large left lower dental plate (Pl. 37, fig. 7).

That this species occurs in rock of Tully age, is evidenced by the following:

E 2402 Upper dental plate, 17 mm. in length.
Pyrite layer of the Tully horizon, Cazenovia Creek, Springbrook, N. Y. Collected by W. L. Bryant.

Ptyctodus compressus? Eastman

E 1892 An imperfect dental plate.
Hamilton limestone (Mid. Devonic); Milwaukee, Wis. Collected by Mr. Edgar E. Teller.

E 1893 An imperfect dental plate.
Formation and locality same as preceding.

Ptyctodus howlandi, n. sp.

(Pl. 38; text-fig. 38)

E 1919 *Type.*—Left lower dental plate. Length 102 mm.; depth at center, 22.

Horizon and Locality.—Conodont Bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Dental plate elongated, shallow (in outer view), its hinder third rising gently toward the posterior extremity. Depth at middle of element contained $4\frac{3}{4}$ times in its length. Oral margin consisting of a prominent "beak," followed by a cutting edge extending to end of second third of the oral margin, at which point there is a depression formed by the opposing upper tritor; then, in last third of element, a broad tritoral area, which rises from inner face outward so as to form with this face a sharp edge especially pronounced in hindermost portion of the tritor. Tritor covered with punctæ, which in its middle

portion are arranged into more or less longitudinal rows, while in the posterior portion, where they are extremely numerous, they are arranged into rough lamellæ. Side walls covered with similar polished rugosities and irregular punctæ so characteristic that even the smallest fragment of this species can be easily identified. Symphyseal region prolonged downward in a short spiniferous process (this is not shown in the type, but is seen in a paratype—E 2426).

Remarks.—This species is represented in the collection by the type, a specimen referred to above as the paratype, and a number of other

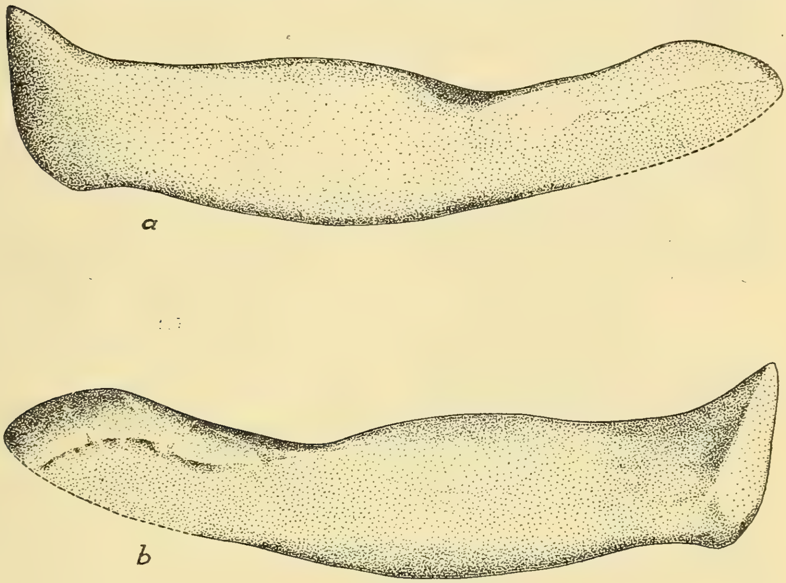

FIG. 38. *Ptyctodus howlandi*, n. sp. LEFT LOWER DENTAL PLATE IN OUTER (*a*), AND INNER (*b*), VIEWS. TYPE; NATURAL SIZE. E. 1919

dental plates more or less perfectly preserved. The type and paratype are practically perfect. They indicate a well-marked species readily distinguished from all others. The special peculiarity of this species lies in the fact that the tritoral region is divided by a depression formed by the opposing upper tritor into two portions: an anterior portion forming a sectorial edge just behind the beak and thickening a little posteriorward; and a posterior portion—a tritor remarkable for the fact that its outer face is a sharp edge, so that the dental plate in this region was at once sectorial and tritorial in function.

P. howlandi is at once distinguished from the four or five other known species, by its size and form, its pronounced beak associated with relative shallowness in outer view, and by the remarkable knife-edge formed by the outer margin of the posterior tritor.

The species is named for Mr. Henry R. Howland, of the Buffalo Society of Natural Sciences, in appreciation of his interest in the development of the fish collection in the Buffalo Museum, and of the encouragement he has given us in the preparation of this catalog.

The following specimens are all from the type locality and were collected at various times during the past four years by Mr. Bryant.

E 1920 Right lower dental plate, perfect as far back as the hinder portion of the tritor. The beak is rather low and worn, and the cutting edge following it is also much worn.

E 1926 Two fragments of dental plates exhibiting a portion of a narrow tritor joining a sharp edge. The tritor is much worn so that the line joining it with the cutting edge rises almost perpendicularly (Pl. 40, figs. 2, 3). No complete specimens of this type of dental plate have yet been collected, and it is possible that when one is found, it may turn out to be a distinct species.

E 2412 A number of fragmentary tritors and sectorial margins of dental plates of various sizes.

E 2413 An imperfect right lower dental plate somewhat larger than the type specimen. It shows the greater portion of the tritor and about half of the pre-tritoral region.

E 2414 Anterior half of an upper dental plate. The beak is low and rounded, and the cutting edge behind it very sharp and unworn (perhaps a young specimen). Only the front portion of the tritor is present. Length from anterior margin to end of cutting edge, 33 mm.

E 2415 Two imperfect dental plates of specimens about as large as the type. They show the greater portion of the anterior cutting edge and about half of the tritor behind it.

E 2416 Tritor of a rather large dental plate, larger than the preceding. It narrows anterior-ward and lacks only about 0.5 cm. of the front end.

E 2421 Complete right lower dental plate of a mature individual (Pl. 38, fig. 6).

E 2425 Three beaks of lower dental plates, about as large as the type specimen.

E 2426 A left lower dental plate somewhat smaller than the type (Pl. 38, fig. 2). It is one of the most perfect specimens found, and shows well the characters of the species. Total length, 86 mm. (including 3 mm. allowed for missing posterior extremity); depth at about middle of element, 21 mm.

E 2427 An incomplete right lower dental plate of an older specimen than the preceding. That it is older is shown by the blunt, worn-down condition of the cutting edge behind the beak, which has the appearance of a tritor rather than a cutting edge. Only the front region of the tritor proper is preserved.

E 2429 An imperfect left lower dental plate on limestone, shown in inner view. The beak as well as the greater portion of the functional margin are lacking, so that it is not absolutely certain that the specimen belongs to this species; it resembles this species, however, more than any other.

E 2434 Fragmentary dental plate showing the greater portion of the pre-tritoral cutting edge and the front half of the tritor of a rather young specimen.

E 2437 Well-preserved beak of a large lower dental plate.

The following specimens perhaps also belong to *Ptycodus howlandi*, but this cannot be asserted positively. They are also from the Conodont Bed at Eighteen Mile Creek.

E 2456 Three anterior extremities of upper dental plates of different sizes.

Ptyctodus ferox Eastman

Specimens collected by Mr. E. E. Teller from the Hydraulic Limestone, at Milwaukee, Wis.

E 1890 Complete lower dental plate, somewhat crushed; in matrix. Length, 13 cm.; greatest depth, 6.

E 2442 Cast of a complete left lower dental plate. Length, 12 cm.; depth at symphysis, 7. Original in Mr. Teller's private collection.

E 2443 Cast of a complete left upper dental plate 15 cm. in length. The upper dental plates are much more sigmoidally flexed than the lower. Original in Mr. Teller's private collection.

Rhynchodus excavatus Newberry

E 1879 Left lower dental plate.
Hamilton limestone (Mid. Devonic); Milwaukee, Wis. Collected by Mr. E. E. Teller.

E 1880 Right lower dental plate. Same as preceding.

E 1881 Right lower dental plate. Same as preceding.

Rhynchodus telleri, n. sp.

(Text-fig. 39)

E 2436 *Cotypes.* (1) A dental plate lacking the beak, embedded in matrix and shown in outer view. The functional margin is entirely free from matrix. Length 67 mm.; depth at about middle, 14.

E 1927 (2) An incomplete dental plate, free of matrix, showing the greater portion of the cutting edge.

Formation and Locality.—Conodont bed (Genesee), Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Dental plate relatively slender, its maximum depth about $\frac{1}{4}$ the total length. Functional margin a sharp cutting edge with a well-

pronounced beak; not perfectly straight, but with a gentle elevation at a point somewhat in front of the middle of the element, from which it falls away gently on either side. Below the beak a spiniferous process.

Remarks.—This species is readily distinguished by the proportion of length to depth of the element; by the gentle undulation of the cutting margin and by the strong beak.

We take pleasure in naming this species for Mr. Edgar E. Teller, of Buffalo, N. Y., in appreciation of his valuable work in collecting and studying the Devonic fishes, especially those of the Hamilton of Wisconsin.

The following specimen probably also belongs to this species:

FIG. 39. *Rhynchodus telleri*. n. sp. DENTAL PLATE, NATURAL SIZE
Cotype No. 1. E. 2436

E 2435 A dental plate in matrix, shown in inner view. The beak is lacking, but the region below it is well shown. This forms a ridge in the region of the symphysis. The anterior two-thirds of the cutting margin is also lacking, but from the posterior third, which is well-preserved, it is seen that the cutting edge extended to the extreme end of the element, as it does also in Cotype No. 1. Total length, 76 mm. (including 2 mm. allowed for missing portion of beak); depth at hinder third (which is perfectly preserved), 13.

Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Rhynchodus ornatus, n. sp.

(Pl. 39, figs. 1, 1a, 2)

E 1950 *Cotypes*. Two left lower dental plates, lacking the posterior extremities. (1) Length, 50 mm.; height (at middle) 20. (Pl. 39, figs. 1, 1a).

E 1950(a) (2) Length, 45 mm.; height 20 (Pl. 39, fig. 2).

Formation and Locality.—Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Dental plate subquadrangular, the upper margin more or less parallel to the lower; symphyseal margin making an angle of about 135° with the inferior margin. Oral margin a cutting blade bevelled by wear on outer face, with a small beak-like projection at its anterior extremity. Symphyseal face bent inward at right angles to the outer face and forming a smooth symphyseal facet about 3 mm. in width, extending downward for about two-thirds the height of the plate, and terminating on its innermost margin in two protuberances, of which the lower one is the larger. Cross-section of dental plate thickest at about one-third its height from the bottom, where it measures 5 mm., and gradually thinning out towards the cutting edge; inner face strengthened by very faint ridges. Outer as well as inner faces of plate ornamented with fine lines running parallel to the long axis; these lines connected with one another at frequent intervals and appearing under the glass as a fine reticulated network; this ornamentation extends almost to the cutting edge of the plate where, however, it is mostly obliterated through wear. In one of the two cotypes, the ornamentation can be clearly seen curving around the front margin of the plate below the symphyseal area.

Remarks.—These two dental plates indicate a highly differentiated species of *Rhynchodus*. This is easily distinguished from all other species by the remarkable ornamentation and the peculiar form. In neither specimen is there any indication of a spiniferous process below the front of the plate.

The symphyseal facet is unusual and worthy of comment. It is bent in at right angles to the outer face of the plate and formed as in *Coccosteus*, except that the five or six symphyseal denticles of the latter, are represented by only two low denticle-like protuberances. It cannot be made out whether the symphyseal edges wer eunited, or were free and more or less functional. They do not show any lines of wear.

E 1947 Two dental plates apparently referable to *Rhynchodus ornatus*, remarkable for the ornamental tubercles on the outer face (Pl. 39, figs. 3, 3a, 4, 4a).

E 1947a Conodont Bed (Lower Genesee); Eighteen Mile Creek, Erie County, N. Y. Collected by W. L. Bryant.

Palæomylus greenei (Newberry)

(Text-fig. 40)

E 1891 Greater portion of a right lower dental plate. The beak of the element is restored in plaster so that the plate looks complete. Length 17.5 cm.; greatest depth, about 9. Hamilton, (Mid. Devonic); Milwaukee, Wis. Collected by Mr. E. E. Teller.

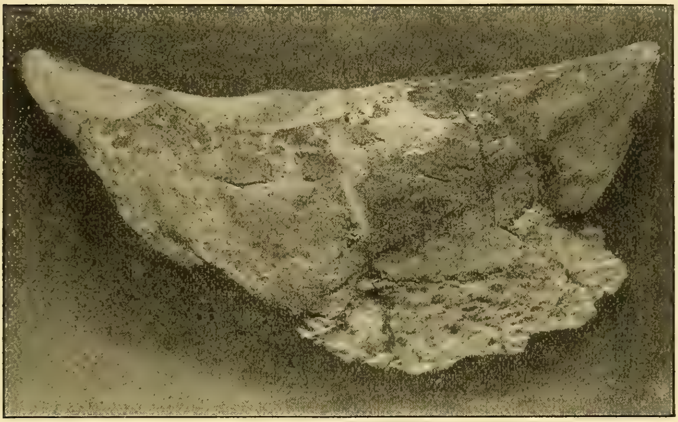

FIG. 40. *Palæomylus greenei* (Newberry). RIGHT LOWER DENTAL PLATE, × ½ Beak and posterior extremity are partially restored. E. 1891

Palæomylus lunaformis, n. sp.

(Pl. 40, fig. 6, and text-figs. 41–42)

E 1928 *Type.* A lower dental plate on a block of limestone. The front half of the specimen is represented only by the impression. Length (slightly restored posteriorly), 84 mm.; depth at about middle, 44.

Formation and Locality.—Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

A species of about the size of *Palæomylus frangens,* gracefully sublunar in outline, with the anterior extremity turned up into a beak.

Front half of functional margin, in profile view, gently excavated; hinder half almost straight and rising gently to the posterior extremity. Posterior part of tritor narrow. [Front portion not preserved.]

Remarks.—This gracefully formed dental plate is readily distinguished from the other three species of *Palæomylus* by its outline. Its front margin rises more abruptly upward than in the other species, and the plate as a whole, disregarding the posterior angle, is relatively deeper in proportion to its length. The difference in outline between this plate and the other three species is clearly brought out in fig. 42,

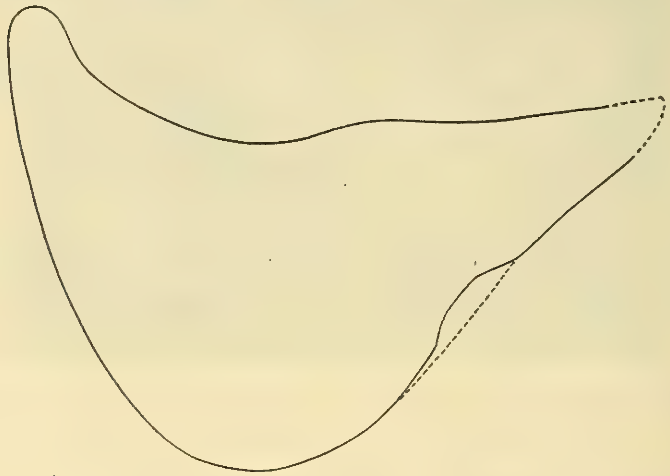

FIG. 41. *Palæomylus lunaformis,* n. sp. OUTLINE OF TYPE DENTAL PLATE, SHOWN IN PLATE 40, FIGURE 6. NATURAL SIZE. E. 1928

The following specimen which is larger than the type, perhaps also belongs to this species.

E 2445 A large imperfect dental plate measuring 13.5 cm. in length as far as preserved. It shows the greater portion of the tritoral area and a part of the outer and inner walls of the element. The tritor is 1.5 cm. at its widest point, and narrows anterior-ward to a sharp edge. Its surface is worn, but it shows no linear arrangement of punctæ.

Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

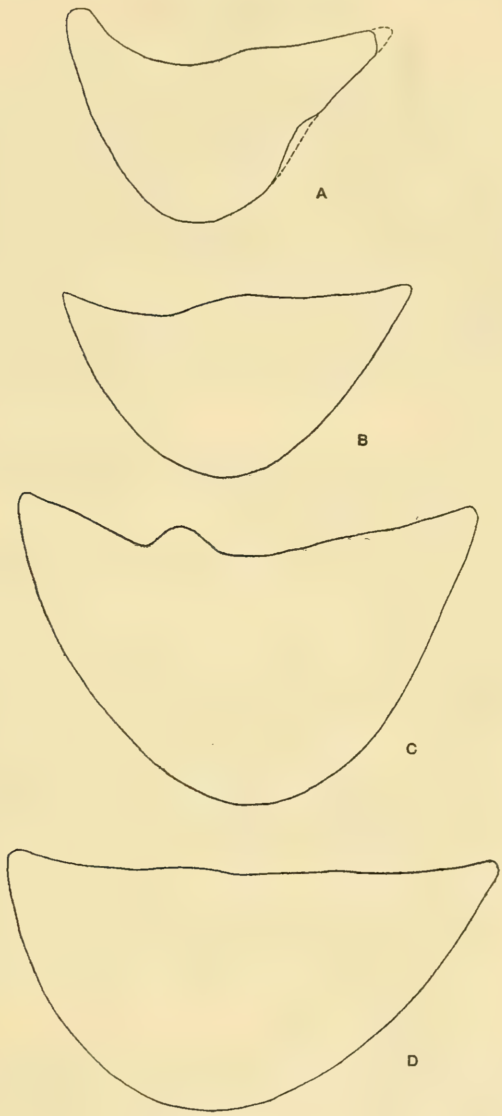

FIG. 42. DIAGRAM KEY TO THE KNOWN SPECIES OF *Palæomylus*, ILLUSTRATING ALSO THEIR RELATIVE SIZES

A, *P. lunaformis*, n. sp.; **B,** *P. crassus*; **C,** *P. frangens*; **D,** *P. greenei.*

Palæomylus sp.

(Pl. 41)

Besides *Palæomylus lunaformis* there is a species resembling *P. greenei* in the Conodont bed at Eighteen Mile Creek; but none of the specimens of it so far obtained is perfect enough to show whether it is this species or a distinct form. It is extremely Chimæroid-like in appearance, the dental plates in oral view being almost exactly like those of *Edaphodon* from the Cretaceous of New Jersey. The anterior extremity rises into a short beak, and the oral margin has two large tritors, an anterior one situated close to the inner margin, and a posterior one near the outer margin. The symphyseal area is very broad, extending inward as far as the first tritor, from which point it descends in a sharp line.

It is to be hoped that complete elements of this interesting species may be found, for they will, no doubt, add considerably to our present knowledge of the genus *Palæomylus*.

The following specimens are all from the Conodont bed (Genesee), at Eighteen Mile Creek, near North Evans, Erie County, N. Y.; collected by W. L. Bryant.

E 2446 Right lower dental plate (Pl. 41, figs. 1, 2). The oral margin is preserved from the beak to a distance 2 or 3 cm. behind the second tritor, and shows well the structure of these parts. The beak, under a lens, shows tritoral columns rising to the surface. In the second tritor, the worn surface is much convoluted by narrow, line-like ridges arranged in curves and circles. Length, as far as preserved, measured along oral margin, 9 cm.; width of oral margin immediately in front of first tritor, 25 mm.; tip of beak to origin of first tritor, 31 mm.; anterior margin of first tritor to origin of second, 24 mm.; width of symphyseal area, 27 mm.

E 2453 Beak of a left lower dental plate belonging to a specimen of about the same size as the preceding. (Pl. 41, figs. 1, 2, part.)

E 1929 and E 1930 Fragments of three dental plates showing portions of the oral surface and the second tritor. (Pl. 41, figs. 3–5.)

E 2452 Beak of a left lower dental plate.

E 2447 Tritoral region of a dental plate, much worn by use.

Palæomylus sp. [Juvenile?]

(Pl. 40, figs. 4, 5)

E 2448 A small dental plate with the greater portion of its outer face embedded in matrix. Total length 29 mm.; height at beak 13. The beak is clear of matrix on all sides and well preserved. This and the functional margin are considerably worn. A striking feature about the element is that the outer and the symphyseal faces are at right angles to each other, forming a sharp ridge along the front of the beak.

This element is probably a juvenile dental plate of *Palæomylus*. The reasons for referring it to this genus are: (1) its general form and the presence of two small tritors back of the beak; (2) the fact that the tritoral region shows the ends of tritoral canals forming the characteristic ptyctodont rugose wearing surface.

Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

E 2449 Impression of the oral margin of a small palæomylid dental plate, together with a cast made from it. (Pl. 40, fig. 5.) It shows the beak and the two tritors very perfectly.

Pyrite layer of the Tully horizon; Cazenovia Creek, near Springbrook, N. Y. Collected by W. L. Bryant.

Deinodus bennetti. n. gen., n. sp.

(Pls. 42, 43)

E 1856 *Type.*—Dental plate in limestone, shown in outer view; in counterpart. The specimen is slightly defective posteriorly, and also at the upper end of the symphysis.

Formation and Locality.—Onondaga Limestone (Mid. Devonic); Cement Quarry, Buffalo, N. Y. Collected by W. L. Bryant.

Dental plate subrectangular, its depth contained about twice in the length. Functional margin a grinding edge worn on outer face,

gradually narrowing toward anterior extremity, which is a sharp beak-like point. Anterior margin straight, without spiniferous process. Outer face of plate ornamented with large, non-stellate tubercles which have a tendency to fuse into irregular masses. Plate thickest posteriorly, thinning anterior-ward.

[*Deinos*, fearful, terrible; *odous*, tooth.]

The species is named for Mr. Lewis J. Bennett, the owner of the Buffalo Cement Quarry, and an Honorary Director of the Buffalo Society of Natural Sciences. To Mr. Bennett's interest in the fossils found in this quarry is due the magnificent collection of Eurypterids in the Museum, regarded as one of the finest in the world, and obtained at considerable expense to him by his paying the workmen premiums for discovering specimens. It was in this quarry also that the type of the present species was found.

Remarks.—These extraordinary dental plates are so unlike any others known, that we have no hesitation in basing a new genus upon them. They apparently belong in the same category with the rhynchodont type of dental plate. But the ornamentation of the outer face is a most extraordinary character, clearly indicating that this face was not covered with soft tissue in life.

In the same formation with these dental elements occur fragmentary plates with similar tubercles, which evidently belong to the same fish. These plates, both in shape and ornamentation, are very suggestive of certain Carboniferous plates and spines from the Mountain Limestone of Armagh, Ireland, figured by J. W. Davis[48a] and ascribed by him to *Oracanthus milleri* Agassiz. In the same rock with these are found spines of the so-called *Oracanthus* which has since been demonstrated by A. S. Woodward[48b] to belong in the family of Gyracanthidæ.

Among the specimens in the Buffalo Museum are three nearly complete spiniferous plates, exceedingly like those figured by Davis, plate 65, figures 3 and 4. In our examples, however, the ornamental denticles are more discrete.

From the same Mountain Limestone, Davis figured under the generic title "*Rhamphodus*," certain problematical dental plates which in profile are exceedingly suggestive of *Rhynchodus*. These dental plates were considered by Davis, and later by Woodward, to

[48a] Davis, J. W.: On the fossil fishes of the Carboniferous limestone series of Great Britain *Trans. Roy. Dublin Soc.*, [2], I, 525; pl. 62, figs. 3, 4, 7, 13; pl. 65, figs. 3, 4. 1883

[48b] Woodward, A. S.: On a Carboniferous fish fauna from the Mansfield District. *Mem. Victoria Nat. Mus.*, Melbourne, I, 1–32, 1906.

be the front teeth of a Cochliodont shark, and it is a curious fact that Jaekel[48c] later proposed the same generic name for certain Ptyctodont plates indistinguishable from those of *Rhynchodus*.

It is obvious, from the new dental plates of *Rhynchodus* and of *Mylostoma* described in this catalog, that the range of variation among these forms has not hitherto been fully appreciated. These groups apparently varied in many different directions, producing a bizarre series of forms which we are only now first beginning to recognize. Evidence is accumulating that the gap between the Rhynchodonts and the Arthrodires will be bridged when these groups, particularly the first, have become better known.[49] Even among the specimens now in hand, there are a number that puzzle one as to whether they should be referred to the Arthrodires or to the Rhynchodonts.

The following specimens are from the Onondaga limestone (Mid. Devonic). All are from the Cement Quarry—excepting only E 1861, which is from the Park Quarry—Buffalo, N. Y. Where not otherwise indicated, they were collected by Mr. F. K. Mixer.

E 2451 A spine-like element 72 mm. in length, and 18 mm. in width at its wider end, tapering to a point. (Pl. 42, fig. 1.) It is embedded in matrix but can be viewed from three sides; of these the two lateral ones are covered with tubercles, while the face between them is smooth. The denticles are closely crowded, their bases touching, and all point in the same direction,—toward the smooth face. The latter consists of hard, smooth bone, and may have functioned as a tritor. The opposite side, as shown by other specimens, is excavated with roughened vascular surfaces as though for a pulp cavity.

E 1860 Dental plate.

E 1861 Robust, conical, tuberculated, fragmentary tooth or spine.

E 1862 Fragmentary, tuberculated plate. Collected by W. L. Bryant.

E 1863 Fragmentary tuberculated plate.

48c Jaekel, O.: Ueber *Rhamphodus*. *Sitzungsber. Ges. Naturforsch. Freunde*, 1903, p. 392.
49 Dollo, Louis.: Les ptyctodonts sont des arthrodires. *Bull. Soc. Belge de Geol.*, xxi, 12 pp., pl. *ii*.

E 1864 Fragmentary spine-shaped plate, tuberculated on the edges. Collected by W. L. Bryant.

E 2460 Fragmentary plate, in matrix, ornamented with flattened, non-stellate tubercles; perhaps this species (Pl. 43, fig. 1).

E 2461 Pointed dental (?) plate in oral view (Pl. 42, fig. 2). The side walls are ornamented with tubercles, and underneath is a broad cavity extending the entire length of the specimen. Collected by W. L. Bryant.

E 2463 Spine-like plate resembling a specimen figured by J. W. Davis, from Armagh, Ireland (*Trans. Royal Dublin Soc.*, [2], I, pl. 62, fig. 13).

E 2464 Fragmentary plate, probably portion of a dental plate, in matrix. Near one extremity are a few obscure denticles.

E 2466, E 2467 and **E 1868** Three elongated, spine-like plates closely resembling a specimen figured by J. W. Davis (*Ibid.*, pl. 65, figs. 3, 4), excepting that our specimens apparently terminated distally in a conical point.

E 2468 An imperfect, triangular, spine-like element, suggestive of an *Oracanthus* spine. (Pl. 43, fig. 3.)

E 2469 Fragmentary spine-like plate seen in longitudinal section.

E 2493 Sigmoidally flexed plate shaped like an upper dental of *Ptyctodus*, the beak compressed and rounded, and behind it a cutting margin expanding posteriorly into a tritor-like area. Under surface excavated as a pulp cavity. (Pl. 43, fig. 2.)

Ptyctodontidæ indet.

E 2472 Fragmentary dental plate, in matrix, showing a pronounced anterior beak, and a secondary acute cusp a short distance behind it; the latter separated from the beak by a deep, semi-circular excavation.

Conodont bed (Genesee); Eighteen Mile Creek, North Evans, Erie County, N. Y. Collected by W. L. Bryant.

E 2473 Another specimen similar to preceding.

E 1882 and **E 1883** Two dermal plates of the kind frequently associated with rhynchodont dental elements in various Devonic formations, e.g., the Hamilton of Milwaukee, the Cedar Valley limestone of Iowa, the Mid-Devonic of the Eifel district of Rhenish Prussia and the Upper Devonic of Wildungen. They have been regarded by Eastman as belonging to ptyctodonts[50] a view which seems quite probable; but no specimen has yet been found with these plates in position, so as positively to establish this view.

Hamilton limestone; Milwaukee, Wis. Collected and presented by Mr. Edgar E. Teller.

ELASMOBRANCHII

[*Sharks and Rays*]

The sharks, living and extinct, are divisible into four great groups:

1. Pleuropterygii (*Cladoselache*, *Cladodus*, etc.).
2. Acanthodii (*Acanthodes*, *Diplacanthus*, etc.).
3. Ichthyotomi (*Pleuracanthus*, *Diacranodus*).
4. Euselachii[50a] (Example: any living species of shark).

Of these groups, the first three are entirely extinct; the fourth comprises both extinct and living forms.

All four groups are represented by good materials in the Buffalo Museum.

I. Pleuropterygii

In the summer of 1914, Mr. Bryant visited the Cleveland shale locality in Ohio and obtained among other things, nine specimens of *Cladoselache*. Some of them are splendid, complete sharks of great interest and two or three throw light on some of the less-known species.

The species of *Cladoselache* represented in the collection are the following:

1. *Cladoselache acanthopterygius*
2. *Cladoselache brachypterygius*
3. *Cladoselache desmopterygius*
4. *Cladoselache eastmani*

[50] *N. Y. State Museum, Mem.* 10, p. 73, 1907. One such plate is there figured, pl. i, fig. 6.

[50a] This group name was introduced by O. P. Hay in 1902, to include all the sharks excepting groups 1 to 3 named above. Bibliog. and Catal. N. Amer. Vert. *U. S. Geol. Survey, Bull.* 179, p. 274.

5. *Cladoselache fyleri*
6. *Cladoselache kepleri*
7. *Cladoselache newberryi*

All, excepting *C. eastmani*, which is from New York State, are from the Cleveland shale (Upper Devonic), near Cleveland, Ohio.

Cladoselache acanthopterygius Dean

(Pl. 45, and text-fig. 43)

[Mem. Amer. Mus., ix, 240, fig. 27, 1909]

This is one of the rarest of the Cleveland shale sharks, easily recognized by its narrow pectoral fins. A single specimen is in the collection.

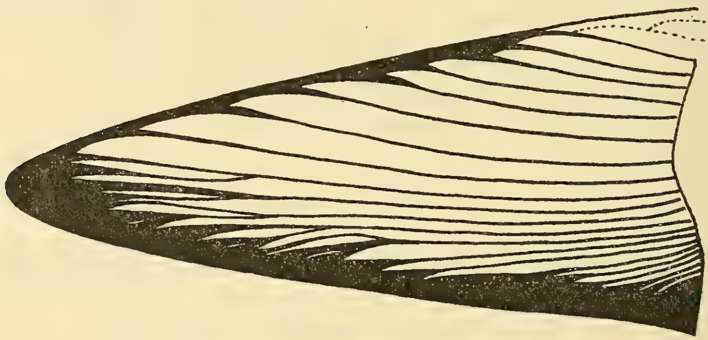

FIG. 43. *Cladoselache acanthopterygius.* PECTORAL FIN, NATURAL SIZE. E. 2474

The name *acanthopterygius*, is not a happy one, since it suggests the presence of a spine on the fin, which of course is not the case with any Cladoselachian; nor is the pectoral fin itself quite so narrow as to resemble a spine (see fig. 43).

E 2474 A large shark lacking the head. It shows the entire body as far back as the caudal fin, both pectorals, and the caudal lateral keels. A number of cladodont teeth are included in the body in the region back of the pectorals; they are either remains of a smaller shark which had been ingested, or teeth which have become shifted from the jaw region of this specimen.

Measurements:	*cm.*
Distance from pectoral fins to tip of caudal........	45.0
Span across pectorals..........................	26.0
Base of pectoral...............................	3.5
Length of pectoral.............................	9.0

As seen from these measurements, the pectoral (fig. 43) is nearly three times as high as wide, and can therefore be compared only with that of *C. acanthopterygius*. It has 14 to 16 primary rays and 8 secondaries; the latter are closely crowded and partly overlap. Tertiary rays, if present, cannot be distinguished in this specimen.

Cladoselache brachypterygius Dean

(Pl. 46)

[Mem. Amer. Mus., ix, 240, pl. xxxii, and text-figs. 22, 23, 1909]

E 2475 We refer to this species a large, fairly well-preserved shark about $3\frac{1}{2}$ feet in length, lacking the caudal extremity. We base our determination on the relative shortness of the pectoral fins, and on their ray formula. The specimen shows both pectoral fins, and a single dorsal. The latter lies in a plane at right angles to that of the pectorals. The pectoral is broad in proportion to the size of the fish, its base measuring about 14 per cent. of the total length of the shark. In the head region, the orbits, jaws and teeth are preserved, and farther back are some muscle segments. The ventral fins are not preserved.

The pectoral fin is relatively short, its height being only a little greater than its base, due to the prolongation of the fin-fold. Its extremity is broadly rounded, not drawn out to a point. The hinder web extends beyond the rays, and is prolonged for a short distance along the side of the body. The fin has 21 primary, 9 secondary, and 2 tertiary rays.

The position of the dorsal seems to be more forward in this species than in *C. fyleri*. This fin shows 19 primary rays, rather crowded together, but no secondary rays can be distinguished.

Measurements:	cm.
Length, as far as preserved (to a short distance posterior to origin of caudal keels)	69.0
Tip of stout to origin of caudal	64.0
Tip of snout to line through origin of pectorals	18.0
Span across pectorals	33.0
Base of pectoral	10.5
Length (that is, height) of pectoral	12.0
Point midway between termination of pectoral membranes to origin of dorsal	7.0
Base of dorsal	7.0
Height of dorsal	7.5

Cladoselache desmopterygius Dean

(Pl. 47, and text-figs. 44, 45)

[Mem. Amer. Mus., ix, 240, pl. xxix, and text-fig. 24, 1909]

This species is distinguished from *C. fyleri*, to which it is most closely related, by its relatively larger fins, their difference in radial formula, and by other points brought out in the description of the individual specimens below. The species is represented in the collection by three specimens.

E 2476 Front half of a shark of medium size. It shows only one of the pectorals (fig. 44), and but one ventral. The head, which is well-preserved, seems to have been more pointed, at least as far as the state of preservation of the specimen indicates, than in some of the other Ohio cladoselachians. It exhibits seven robust gill arches; and there are eight or nine banks of teeth shown in the left half of the jaw. There seems no doubt that this specimen is correctly referred to *C. desmopterygius*.

The pectoral has 19 primary rays, 12 secondaries and 14 tertiaries; the ventral, 9 primaries and 2 secondaries.

Measurements:	cm.
Tip of snout to origin of pectoral	20.0
Distance between posterior termination of pectoral and origin of ventral	19.5
Base of pectoral	7.5
Length of pectoral	9.2
Base of ventral	3.0
Length of ventral	2.0

E 2477 A nearly complete fish. It exhibits only a single pectoral, and this is partly destroyed owing to its having been exposed in the concretion and having become weathered before it was collected. It shows both orbits indicated by the sclerotic rings; several (at least five) banks of teeth, (it is seen that these teeth overlap at their bases); also neural arches, and fossilized muscle-tissue, arranged in segments, near the pectoral fins. In the region of the alimentary canal some ingested matter is to be seen,

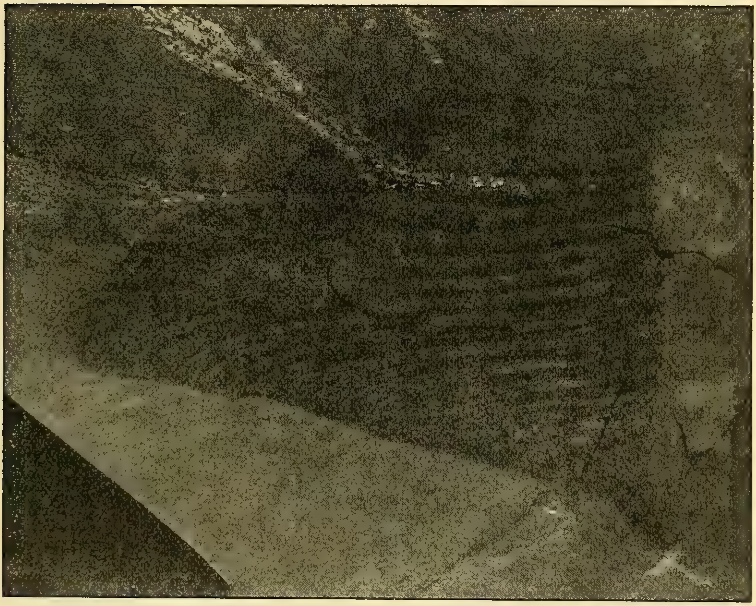

FIG. 44. *Cladoselache desmopterygius.* PECTORAL FIN OF SPECIMEN E. 2476

including scales, and a striated tooth (the latter destroyed in cleaning the specimen).

The pectoral fin is large, elongated, and situated relatively far back, as is characteristic of this species. It shows 20 primary and 4 secondary rays. There are also indications of tertiary rays, but they cannot be counted.

E 2478 Body of a shark, with the pectorals, ventrals, and one dorsal (fig. 45), probably belonging to *C. desmopterygius.*

The pectorals are fairly well preserved. They show 19 or 20 primary, 8 secondary, and 8 tertiary rays. There were probably several additional tertiaries, but they are not shown. The shagreen covering the pectoral fin is present in places, and the fin itself seems thick and fleshy. Both ventral fins are preserved. They are rather small, and broken posteriorly, but probably ran out into narrow

FIG. 45. *Cladoselache desmopterygius.* BODY OF A SHARK, DISPLAYING THE PECTORALS (*p*), VENTRALS (*v*), AND ONE DORSAL (*d*). × ¼. E 2478

membranes along the margins of the body. They show 9 or 10 primary, and 6 secondary rays; there are, apparently, no tertiaries. In addition to the pectorals and ventrals, there is another fin present, evidently the dorsal. It is situated 11.5 cm. behind the posterior margin of the pectoral. It shows 10 primary rays and 5 secondaries; its height is 3 cm., and base 3.5.

Measurements:	*cm.*
Base of pectoral	10.5
Length of pectoral	13.0
Span across pectorals (restored)	38.0
Span across ventrals	12.0
Base of ventral	4.0
Height of ventral	2.5
Posterior termination of pectoral membrane to origin of ventral	19.5

Cladoselache eastmani Dean

(Text-fig. 46)

Cladoselache sp. indet., EASTMAN, N. Y. State Museum, Mem. x, 57, pl. 8. 1907.

Cladoselache eastmani DEAN, Mem. Amer. Mus. Nat. Hist., ix, 240, text-fig. 25 [figured upside down]. 1909.

This species is known only by a pectoral fin, preserved in the Buffalo Museum. The specimen is of great interest since it is the only

FIG. 46. *Cladoselache eastmani*. PECTORAL FIN. TYPE AND ONLY KNOWN SPECIMEN. × about $\frac{2}{5}$. E 2027

example of *Cladoselache* thus far found in New York State, and with one other exception,[51] the only one found in any formation outside the Cleveland shale of Ohio.

E 2027 A fin of large size, the base measuring 180 mm. and its length 260 mm. It is remarkable for its narrow pointed form, and for the large number of rays, which are very slender, and about 80 in number. Secondary and tertiary rays are apparently absent. It represents a shark about 4 feet in length.

It should be pointed out that while this specimen is close to *Cladoselache*, and may for the present be left in that genus, still its narrowness, the great number of its rays which far exceeds that found in any other species of *Cladoselache*, may ultimately necessitate its being placed in a distinct genus.

From a concretion found in the Rhinestreet shale, shore of Lake Erie at the mouth of Eighteen Mile Creek, Erie County, N. Y. Collected by Dr. Herbert U. Williams.

Cladoselache fyleri (Newberry)

(Pl. 48)

This is the most abundant species of shark in the Cleveland shales. It is represented in the collection by a splendid specimen.

E 2480 A complete shark shown in ventral view, with the pectorals expanded. The ventrals are missing. The caudal is seen in section. In the precaudal region the horizontal keels are beautifully shown, standing out sharply through the contrast of their black color. In the head region the jaws are shown, although somewhat shifted from their proper position. A number of teeth are present; they exhibit fine striations on the central cusps, and in some of them extremely small denticles are present between the main and the lateral cusps. The sclerotic rings are well preserved. The pectoral shows 20 primary rays and 8 secondaries; no tertiaries are apparent.

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[51] The other exception is a caudal fin in a small nodule from the Waverly (basal Carbonic) of Kentucky [No. 7583 Amer. Mus.]. *Mem. Amer. Mus. Nat. Hist.*, ix, 241, fig. 17.

Measurements:	*cm.*
Total length	39.0
Tip of snout to line through origin of pectorals	8.0
Span across pectorals	14.0
Base of pectoral	3.5
Length (that is, height) of pectoral	4.5

Cladoselache kepleri (Newberry)

(Pls. 49, 50; text-figs. 47, 48)

This is the largest of the Ohio Cladoselachians, reaching a length of 6 feet. Its large fins, with broad, stout rays, are usually in magnificent preservation, and show the details of the fin structure better than any other species. This form is represented in the Buffalo Museum by a fine specimen over 5 feet in length, and by a portion of a second, consisting of the region of the ventral fins.

E 2481 A nearly complete shark showing the head and almost the entire body as far as the tail; both pectorals, one ventral, and the upper lobe of the caudal. The specimen shows considerable detail: the eyes, teeth, branchial bars, neural arches and shagreen (Pl. 49).

The pectoral is somewhat longer than wide at the base, the ratio being 9 to 7. The rays are clearly shown; there are 20 primaries, 10 secondaries and 3 tertiaries.

The ventral is not perfectly preserved at its posterior extremity, but the web was apparently drawn out into an elongated, pointed flap, as in other species in which it has been observed. It exhibits 14 primary rays and 3 secondaries; there are no tertiaries.

Measurements:	*cm.*
Length as far as preserved	160
Length, to (about) origin of caudal	156
Tip of snout to line through origins of pectorals [about 21 per cent. of length of fish]	36
Tip of snout to line through origin of ventral	93
Base of pectoral	14
Length (or height) of pectoral	18
Base of ventral	10+
Length (or height) of ventral	7

FIG. 47. *Cladoselache kepleri.* *A*, PECTORAL; *B*, VENTRAL; BOTH OF THE SAME SHARK. × ½. Stippled portions restored. E 2481

E 2482 Portion of the body of a large shark with the ventral fins, in counterpart (fig. 48). One of these is exquisitely preserved, and exhibits for the first time in this species the narrow posterior prolongation of the web. The base of the ventral measures 16 cm. (including the web to its posterior end); its greatest height is 9 cm.; the span across the ventrals is 34 cm. Our identification of the species as *C. kepleri*, is based on the large size of the shark and on the robustness of the fin-rays. There are 13 primary rays, 5 secondaries, but no tertiaries.

FIG. 48. *Cladoselache kepleri.* VENTRAL FINS, × $\frac{3}{8}$. *p*, pelvic fin-support. E 2482. (See Pl. 50)

This specimen exhibits one of the most perfectly preserved ventral fins ever found. There are only two other examples of ventral fins known that compare with it—one in the American Museum,[52] the other in the British Museum.[53] Both of these are ventrals of *Cladoselache fyleri*, and neither shows the details of structure quite so clearly as the present specimen. In the American Museum specimen there is no cartilaginous rod extending into the posterior prolongation of the fin-web. In the British Museum specimen it is present, but not so clearly demarcated posteriorly. Prof. Jaekel terms it the "Haupt-

[52] No. 7019 Amer. Mus. *Mem. Amer. Mus. Nat. Hist.*, ix, 224, figure 19, 1909.
[53] Jaekel, O.: Ueber die Beurteilung der paarigen Extremitäten. *Sitzungsb. d. k. Preus. Akad. Wiss.*, xxvi, 707–724, 1909. See especially pp. 713–714, and figure 5.

achse," and represents it as extending the whole length of the web, and, in fact, projecting a little beyond. He regards it as a myxopterygium, and says it terminated in small hooks.[53]

In our specimen the axial rod begins at a distance of 110 mm. behind the anterior extremity of the fin base, and it has a length (measured from the posteriormost radial) of 50 mm. It shows two or three very vague transverse lines; but these are probably mere breaks in the superficial film of the fossil and not an actual segmentation of the rod.

Cladoselache newberryi Dean

(Text-fig. 49)

This species has hitherto been known only by the type specimen, an incomplete small shark, which is perhaps only an immature individual of some other Ohio species. Its status has not been adequately defined, but for the present we retain it provisionally as distinct.

FIG. 49. *Cladoselache newberryi.* PECTORAL FIN, NATURAL SIZE

The posterior margin was outlined in pencil in the specimen before photographing. E 2483.

E 2483 A fragment of a shark exhibiting both pectorals. The base of the pectoral (fig. 49), measures 6.5 cm., and its length 5 cm. It shows 13 primary, and 2 or 3 secondary rays,

but no tertiary rays are to be seen. The fin is rather pointed, and the web is prolonged posteriorly beyond the last ray into a fin-fold, about half as long as the base proper, of the fin.

Family CLADODONTIDÆ

Cladodus coniger Hay

E 2078-9 We refer to this species the impressions of two imperfect teeth from the Catskill beds in Crawford County, Pennsylvania. Each tooth consists of a central cone and two denticles on either side of it, directed laterally. The crowns are marked by striations or carinæ. This species has hitherto been known only from the Chemung.

Top layer of the Second Mountain Sandstone (Catskill); Snodgrass Quarry, Crawford County, Pennsylvania. Collected by J. F. Carll.

Cladodus urbs-ludovici Eastman

(Pl. 44, figs. 1, 1a)

Cladodus urbs-ludovici EASTMAN, Devon. Fishes Iowa, 110, pl. iii, fig. 3. 1908.

Three cladodont teeth from the Conodont bed represent this species, which was hitherto known only by the holotype. an imperfect tooth, from the New Albany shale (Genesee) of Kentucky. It is interesting as adding another to the three or four species common to the New Albany shale and the Conodont bed.

Since the original description of the species was based on a single imperfect tooth, which did not show the root well, and also lacked the distal half of the crown, it seems desirable to give a revised description of the species, based on our three specimens.

Description.—Tooth a large, somewhat compressed cone, rising from a laterally expanded base. No lateral denticles. Crown elliptical in cross-section, with sharp lateral keels; the posterior face somewhat more convex than the anterior. Both faces ornamented with very fine, parallel, vertical lines which end abruptly at the merging of the crown and base. Apex of crown reflexed slightly forward. Base rather compressed antero-posteriorly, laterally expanded, with

its outer extremities apparently directed somewhat downward; upper surface of base, near cone, rounded.

E 1899 Tooth, 12.5 mm. in height, on a piece of matrix.
Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

E 1900 Tooth, 20 mm. in height, free from matrix. Other data same as preceding.

E 2484 An acutely-pointed tooth, lacking the lateral extremities of the root, in matrix. Height, 16 mm.; width of cone, at base, 5 mm. Other data same as preeeding.

II. Acanthodii

The Acanthodians are not as abundantly represented in America, either in species or individuals, as in Europe. There are only a few specimens in the Buffalo Museum. These include a fine example of *Acanthodes concinnus;* a fin-spine from the Conodont bed, and two spines of *Gyracanthus.* The last are now positively known to be Acanthodians through having been found in their natural position in unquestioned Acanthodian sharks, from the Carbonic of Victoria, Australia described by Smith Woodward, in 1906,[54] under the name *Gyracanthides murrayi.* Dr. Woodward separated these Acanthodians from the rest as a distinct family—*Gyracanthidæ.*[55] Some of these forms, judging by the size of the pectoral spines, must have reached considerably larger proportions than the other Acanthodidæ, attaining a length of several feet.

It has been suggested, also, that the spines known as *Machæracanthus* probably belonged to Acanthodians. This view is highly probable; indeed it may be regarded as almost established, in view of the close resemblance between certain of the smaller species of *Machæracanthus* and the fin-spine of Acanthodians; and also the approximation of some of the species to certain *Gyracanthus* spines. But as none of these spines has yet been found in natural association with the fish to which it belonged, there must still remain a slight uncertainty; and hence we follow the older view of placing the genus *Machæracanthus* among the Ichthyodorulites.

[54] Woodward, A. S.: On a Carboniferous fish fauna from the Mansfield District, Victoria. *Mem. National Mus.*, Melbourne, 1, pp. 1–32, pls. i–xi, 1906.
[55] *Loc. cit.*, p. 3.

Acanthodes concinnus Whiteaves

(Pl. 51, figs. 2, 4; text-fig. 50)

Among the specimens collected by Mr. Bryant in the Upper Devonic at Scaumenac Bay, Quebec, in 1915, is a large example of *Acanthodes concinnus*, 29 cm. in length. This is about twice the size of the largest specimen figured by Whiteaves,[56] and thus proves that the species attained much larger proportions than was hitherto supposed. The species is readily distinguished by the scale ornamentation (Pl. 51, fig. 2), and by the relatively weak spines.

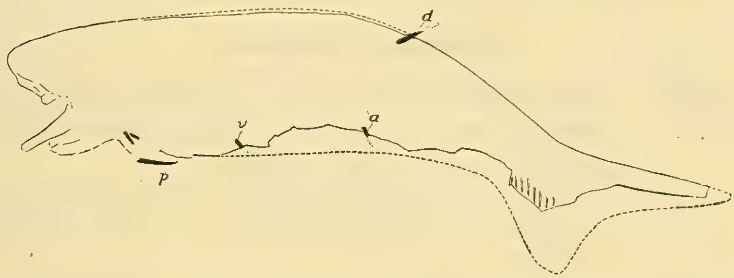

FIG. 50. *Acanthodes concinnus* Whiteaves. OUTLINE OF A NEARLY COMPLETE SHARK. × $\frac{1}{3}$

All the fin-spines are present (although incompletely preserved), and apparently in their proper positions.

a, anal fin-spine; *d*, dorsal; *p*, pectoral; *v*, ventral. The two fragments of spine seen in front of the pectorial spine are apparently parts of the fin-spine of the opposite side. Note the ray-like structure in the lower lobe of the caudal. E 2485

E 2485 A shark, 29 cm. in length (fig. 50), in side view, on shale. The ventral margin of the trunk was lost through the flaking out of a thin superficial layer of the rock; and the tip of the caudal for about 1 cm. is also missing. The mouth is widely opened. One pectoral fin-spine is the only spine completely preserved (Pl. 51, fig. 4). It is somewhat shifted from its natural position, and measures 19 mm. in length (incomplete at proximal end?). Of the other fin-spines only the proximal ends are preserved. The dorsal spine is inserted a little back of the middle of

[56] Whiteaves, J. F.: Illustrations of the fossil fishes of the Devonian rocks of Canada. Part I. *Trans. Roy. Soc.* Canada, iv, 107, pl. x, figs. 1, 1a, 1886; Part II, in vol. vi, pl. v, fig. 2, 1889.

the fish; the anal spine, slightly in front of the dorsal; the ventral spines, a little nearer the pectoral than the anal. The caudal had a long upper lobe; its lower lobe shows the impressions of a number of radials.

The shagreen is well shown over most of the fish; its ornamentation (Pl. 51, fig. 2) agrees closely with that figured by Whiteaves.[57] In the caudal extremity, the scales of the lateral line are well shown.

Upper Devonic; Scaumenac Bay, near Village of Migouasha, Quebec, Canada. Collected by W. L. Bryant, August, 1915.

Acanthodian Fin-spine

E 2486 A small spine in matrix (Pl. 51, fig. 3). Length as far as preserved 18 mm.; width, 3 mm. There seems no doubt that this is an Acanthodian spine.

Conodont bed (Lower Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Family GYRACANTHIDÆ

Gyracanthus sarlei, n. sp.

(Pl. 52, figs. 3–5)

E 2487 *Type.*—Proximal half of a small spine, on a piece of shale. Length as far as preserved, 38 mm.; maximum width, 9.

Formation and Locality.[58]—Genesee shale; Canandaigua Lake, N. Y. Collected by Prof. Clifton J. Sarle.

Spine small, 5 or 6 cm. in length. Cross-section an irregular oval, with its narrower side drawn out to a point. Sides ornamented with two sets of striæ, forming V's whose apices are on the rounded ridge running the length of the spine; the striæ on the thin, wing side of the axis, long, smooth and very little inclined toward the axis, while the striæ on cutwater side of spine are shorter, more or less wavy in places,

[57] Loc. cit; Pl. x, fig. 1 a.

[58] There was some uncertainty as to the horizon of this specimen, and we submitted it to Prof. A. W. Grabau, of Columbia University, for examination. He pronounced the matrix to be "undoubted Genesee shale." There are two specimens of *Leiorhynchus quadricostatus* on the same piece of rock.

and form a large angle with the axis. Outer half of the thin, wing side of spine smooth, without ornamentation; on cutwater side ornamentation extends clear to the margin.

Named for Prof. Clifton J. Sarle of St. Lawrence University, Canton, N. Y., who collected this and other specimens now in the Buffalo Museum.

Remarks.—This species differs from the three other American Devonic species known. It is closest to *Gyracanthus primævus* Eastman,[59] from the Marcellus shale; which, however, besides being from a lower horizon, differs in several important points. In *G. sarlei*, the ornamentation extends clear to the cutwater margin, whereas in *G. primævus* there is "a smooth and highly polished enamelled band, adjacent to the front margin." On the other hand, conditions are reversed as regards the ornamentation of the thin, wing margin; in *G. sarlei* the outer half of this margin is smooth and unornamented, whereas in *G. primævus* it is ornamented up to the edge. In *G. sarlei* moreover, the ornamental striæ on the wing half of the spine are less inclined to the axis, being only the least bit off the true vertical, and there are no beadings or tuberculations on the striæ adjacent to the inserted portion as in *G. primævus.*

From *Gyracanthus incurvus* Traquair,[60] from the Lower Devonic of Campbelltown, N. B., *G. sarlei* is distinguished by differences in ornamentation and other details.

From *G. sherwoodi* Newberry, from the Chemung and Catskill of New York and Pennsylvania, it is distinguished by its smaller size, by the striæ being much less inclined to the axis of the spine, and by the absence of tubercles or beading from them.

It is worthy of note that *Gyracanthus sarlei* has considerable resemblance to *Machæracanthus*, and if not for the distinctive *Gyracanthus* ornamentation, would be regarded as a species of this genus. Thus it has a *Machæracanthus*-like cross-section, and a smooth lateral wing, which thins out to a knife edge, as in this genus. It has long been known that *Machæracanthus* has much resemblance to Acanthodian spines; and the present specimen on the one hand, and *Machæracanthus sulcatus* (which has an ornamentation of lines running parallel with the axis of the spine) on the other, help to bridge the gap between these two genera.

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[59] Devonian fishes of Iowa, 114, and text-fig. 17, 1908.

[60] For a figure of this species see Woodward, A. S.: On the Lower Devonic fish fauna of Campbelltown, N. B. *Geog. Mag.*, [3], viii, 1–6, pl. i. figs. 4–5, 1892.

Gyracanthus sp.

(Pl. 52, fig. 4)

E 2489 A small, slender spine, imperfect at both ends, measuring 46 mm. as far as preserved. One face is rounded while the other has a sharp ridge running the length of the spine, somewhat nearer one margin than the other. It is ornamented with two series of fine lines forming a V-shaped arrangement, with the apices of the V's on the ridge. The spine, from its form and ornamentation, undoubtedly represents a species of *Gyracanthus*; but as it may be an immature example, or possibly belongs to *G. sarlei*, it seems to us undesirable to give it a name at the present time. No doubt larger and better specimens will some day be discovered.

Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

III. Ichthyotomi

Genus **Dittodus** Owen[61]

The teeth referred to the genus *Dittodus* belong to Pleuracanth sharks. It is probable that they represent a number of genera, considering their great geological range and the fact that they come from such diverse localities and formations; it therefore seems desirable to retain *Dittodus* as a provisional genus rather than to refer all these teeth to the genera *Pleuracanthus* and *Diacranodus*.

Dittodus priscus (Eastman)

(Pl. 44, figs. 3, 3a, 3b; text-fig. 51)

Diplodus priscus EASTMAN, Journ. Geol., vii, 490, pl. vii, figs. 1, 2. 1899.

This species has hitherto been found only in a peculiar deposit[62] of Upper Devonic age near Elmhurst, Illinois. Associated with it is a second species, *D. striatus*, distinguished by having much finer stria-

[61] As pointed out by O. P. Hay (*Bibl. and Cat. Fossil Vert. N. A.*, p. 265), *Diplodus* is preoccupied and should be replaced by *Dittodus* Owen, which is an available synonym.

[62] Weller, Stuart: A peculiar Devonian deposit in northeastern Illinois. *Journ. Geol.* vii, 483–488 3 figs. 1899.

tions. It is remarkable that the same two species should also be found associated in the Conodont bed at Eighteen Mile Creek.

We have 17 teeth of *D. priscus*, some of them in splendid preservation, showing the entire root, the median denticle and all the characters of the species. These specimens enable us to add somewhat to the account given by Eastman, who had available only imperfect specimens. In the first place, it should be observed that there is considerable variation in size among the teeth, some of the larger ones being twice as high as the smaller ones. Secondly, the ornamentation, which consists of striæ spiraling gently upward from base to tip of tooth, varies considerably in the number and prominence of the striæ. Some teeth have seven or eight striæ, others as many as a dozen or more. Frequently short striæ are interpolated between the long ones in the basal portion of the tooth; or the striæ may be

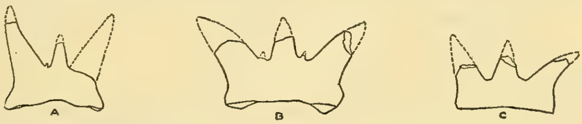

FIG. 51. *Dittodus priscus* Eastman. THREE TEETH. NATURAL SIZE. E 1901

A, a typical *Dittodus* tooth, i.e., with two large lateral cones and an intermediate denticle. **B**, a tooth with the median denticle rather large and a minute denticle between it and each lateral cone. This tooth is of the form usually placed in the genus *Phœbodus*. **C**, a tooth with rather large median denticle but no minute denticles between it and the lateral cones. This is also a *Phœbodus* type of tooth.

reduced on the posterior face, sometimes to only a few short ones confined to the lateral margins. In all the specimens in hand, the central portion of the posterior face is perfectly smooth.

Eastman described the teeth as round in section. From our series it appears that there was some variation in this regard; most of the teeth are slightly compressed, and some at least, have sharp lateral keels. There is also considerable variation in the height of the root, as viewed from in front. In some teeth it is less than the height of the median denticle, in others it is considerably more. The median denticle varies greatly in size in different teeth; it may be quite small, but generally it is large; in two or three examples it is nearly as large as the lateral cones (fig. 51, C). There may be, too, minute denticles between the medium and the lateral cones, producing teeth that if found alone would undoubtedly be ascribed to the genus *Phœbodus*.

E 1901 Nine teeth, varying from 10 to 13 mm. (15 if restored) in height from lower margin of base to apex of principal cones. One shows the complete root with the "button;" another, which lacks the distal halves of the cones and the posterior portion of the root, has a large central denticle, nearly as large as the principal cones. This tooth is of the kind usually referred to the genus *Phœbodus*; but there can be no question that it is of the same species as the other teeth in this lot. The ornamentation is nearly effaced, but it was apparently similar to that in the other teeth. Another tooth lacks all trace of a median denticle; and still another, has a minute denticle on either side, between the median and the lateral cones.

Conodont bed (L. Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

E 1902 Seven teeth, from 9 to 14 mm. in height; 5 have the root well preserved. These teeth have finer striations than the preceding.

Other data same as preceding.

E 2490 One cone with portion of the root of a large tooth, in matrix.

Other data same as preceding.

Dittodus striatus (Eastman)

Diplodus striatus EASTMAN, Journ. Geol., vii, 490, pl. vii, figs. 3, 4. 1899.

This species occurs in the Conodont bed associated with *D. priscus*, but it is very much rarer, there being only a single specimen in the collection. The species was originally described from "only a few fragmentary specimens," and was stated to attain about twice the size of *D. priscus*. Our specimen is a perfect tooth, and smaller than large examples of *D. priscus*. It is distinguished from the latter more especially by the much finer and much more numerous striæ. In our specimen the striæ are not so strongly curved around the tooth. as in the type figured by Eastman.[63] However, as there, no doubt, was variation in this regard, and since our specimen so closely agrees

[63] *N. Y. State Mus., Mem.*, 10, pl. i, fig. 11.

with the description and figures of the type, we do not hesitate to refer it to *D. striatus*.

E 2491 A complete tooth. Total height, 5.5 mm.; width of base, 6; antero-posterior diameter of base, 4.5.
Conodont bed, (Genesee), Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Dittodus grabaui, n. sp.

(Text-fig. 52)

E 1910 *Cotypes.*—Five small teeth, free of matrix.

Formation and Locality.—Conodont Bed (Lower Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Teeth small, 2 to 3 mm. in height, with two or three principal cones, and usually a minute denticle between the median and each outer cone. All cones perfectly smooth, without striations on either the inner or outer face. Root, viewed from in front, broader than high, its height to base of median denticle slightly less than height of outer cones; expanded downward at external margins; a "button" present.

Remarks.—Of this species we have a series of about 50 teeth. Although unquestionably all of one species, they show considerable variation in the size and number of denticles, so that one may arrange them into a progressive series leading from *Dittodus* at one extreme, to *Phœbodus* at the other. The first stage (fig. 52, *A*) is a typical *Dittodus* tooth with two principal cones and a smaller denticle between them; the next is a stage with the median denticle somewhat enlarged; the next (fig. 52, *C*) is like the preceding but with a minute denticle between the median cone and each of the outer cones. Finally we have a tooth (fig. 52, *E*) with three principal cones, the median one being also enlarged, and a pair of minute denticles between the median and each of the outer cones; in other words a *Phœbodus* tooth. (Not as well shown in figure 52, *E*, as in some other specimens in the collection.)

This series demonstrates clearly that *Phœbodus* merges into *Dittodus*.

From the studies of Fritsch,[64] also, it is known that in the Pleura-

[64] *Fauna der Gaskohle und der Kalksteine der Permformation Böhmens*, vol. iii, pl. xciv, fig. 1 (*Pleuracanthus parallelus* Fr.), 1895.

canthidæ the small teeth at the angles of the jaws, and those on the gill-bars, were not of the *Dittodus* form, but had 3, 4 or more cones of about equal size. Some of these were of the form usually referred to *Phœbodus*, although unquestionably Pleuracanth as shown by their position in the mouth of a Pleuracanth. Then, too, there are species of *Dittodus* on record that have more than the usual two large cones—for instance, *Dittodus duplicatus* (Newberry and Worthen),[65] which has sub-equal denticles; and there are two species, mentioned by Agassiz in his *Poissons Fossiles*, one with four,[66] and the other with five[67] denticles.

From this it appears that teeth which could be referred to *Phœbodus* occur associated with *Dittodus* in the dentition of one fish. And from all the specimens in hand it appears that a progressive series may

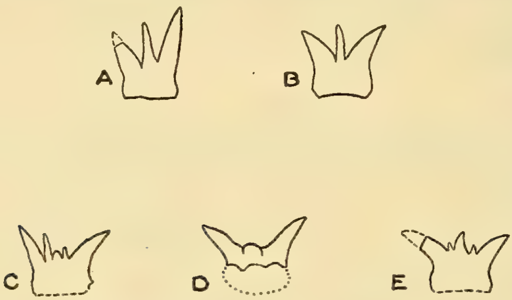

FIG. 52. *Dittodus grabaui*, n. sp. COTYPES. × ABOUT 4

A and *B*, show a large median denticle. *C* and *E*, show minute denticles between the median and lateral denticles. *D*, shows root with the "button."

be arranged, leading by insensible stages from the one genus to the other. Most *Phœbodus* species, it would seem, can be merged in the genus *Dittodus*. The name *Phœbodus* should therefore be retained as a provisional genus only, for teeth of which there is not a sufficient number of specimens to prove their gradation into *Dittodus*.

The species is named in honor of Prof. A. W. Grabau, Professor of Paleontology in Columbia University, as a token of our admiration for his tireless devotion to paleontology, as well as to commemorate his valuable work on the geology and paleontology of Eighteen Mile Creek.

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[65] *Geol. Survey Illinois*, ii, Palæontology, 61, pl. iv, figs. 3, 3a, 1866.
[66] *Dittodus minutus.—Poissons Fos.*, iii, pl. xxiib, fig. 7.
[67] *Ibid.*, iii, p. 204.

Dittodus sp.

E 2028 One tooth, 6 mm. in height, on a piece of black shale. It consists of two cones without a median denticle (perhaps broken away?). The surface of the cones bears a few faint vertical striations, and the tooth may possibly belong in *D. priscus.* The root is injured.

Rhinestreet shale; shore of Lake Erie, near Sturgeon Point, New York.

E 2559 One tooth with fragments of others, somewhat weathered. The ornamentation, if any there was, has entirely disappeared, but in size these teeth are comparable with *D. priscus.*

Pyrite layer of the Tully horizon, Cazenovia Creek, near Springbrook, N. Y. Collected by W. L. Bryant.

IV. Euselachii

Family PETALODONTIDÆ

Petalodus ohioensis Safford[68]

E 2087 One tooth. Bituminous coal series; Northwestern Pennsylvania. Carll collection.

Family PSAMMODONTIDÆ

Psammodus angularis Newberry & Worthen

E 2492 One tooth. Chester limestone? Illinois.

Helodus rugosus Newberry and Worthen

E 2080 One tooth. Carbonic; Crawford County, Pennsylvania. Carll collection

E 2081 One tooth. Carbonic; Franklin, Venango County, Pennsylvania. Carll collection.

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[68] For synonymy of this and the following species, see Hay, O. P.: *Bibl. and Catal. Fos. Vert. N. A.*, 1902, p. 278, *et passim.*

Family COCHLIODONTIDÆ

Synthetodus calvini Eastman

(Pl. 55, figs. 1, 2)

Undescribed dipnoan dental plate—EASTMAN, N. Y. State Mus., Mem. x, 203 pl. iv, fig. 15. 1907.

Synthetodus calvini EASTMAN, Iowa Geol. Surv., xviii, 233, pl. ii, fig. 19; pls. x, xi [in part], xii. 1908.

This species is represented by a single dental plate from the Conodont bed, measuring 46 by 37 mm. (Pl. 55, figs. 1, 2). It agrees well with Eastman's figure of the type (Devonic Fishes of Iowa, Pl. ii, fig. 19), and more especially with his specimen figured in Plate xii, figure 15. The latter figure, which represents a somewhat smaller specimen than ours, might almost have been drawn from ours.

The occurrence of this species in the Conodont bed, is of considerable interest, as it gives us a second species—the other being *Ptyctodus calceolus*—common to this formation and the State Quarry Beds (Upper Devonic) of Iowa.

As regards the nature of these synthetodont elements, which have been described as two species—*Synthetodus calvini* with a single boss, and *S. trisulcatus* with a tripartite division of the wearing surface —we find ourselves unable to concur in the opinion of Eastman that they represent dipnoans. That they are dental plates admits of no doubt; but the dental plates of dipnoans, with their radiating ridges, or rows of tubercles, are among the most distinctive objects known to the ichthyologist; and the present elements are clearly not of that type. They may rather be compared with certain shark dental plates, such as those of *Helodus*. Each element is a flattened plate (Pl. 55, fig. 2), from one face of which rises a boss or tubercle which functioned in triturating, as shown by its wear. And the entire face is covered with a shining enamel (a little worn down on the functional portion), which is sprinkled with small punctæ, such as are seen on the pavement dental plates of various sharks, e. g., *Helodus*. The other face (Pl. 55, fig. 1) of the dental plate consists of bony tissue, roughened with small depressions and postules, and obviously was the side that was set in cartilage, or other soft, nutrient tissue.

Moreover, the elements of both *Synthetodus calvini*, with their single, central boss, and of *S. trisulcatus*, with their tripartite tritor, are bilaterally symmetrical, and there are no rights and lefts among

them as would be expected if they were comparable with the usual palatine and splenial dental plates of dipnoans. On the other hand, they are not of the form to compare with dipnoan plates like *Palædaphus*, in which the upper and the lower dental elements are united into single symmetrical plates. The synthetodont elements rather give the impression of belonging to some sort of dental pavement such as is found in certain Paleozoic sharks.

We may mention here that it seems to us also, that the dental plates from the Upper Devonic of Iowa, referred by Eastman[69] to McCoy's genus *Conchodus*, are also not dipnoan, for they show neither rows of tubercles nor ridges. And their small, postero-lateral prolongation regarded by Eastman as the vestige of a dipnoan denticled ridge, is nothing more than the postero-lateral termination found in many forms of grinding shark teeth, for instance, in *Deltodus*. The *Conchodus* elements may belong to the same pavement as the synthetodont plates.

To conclude, from the evidence at hand the dental plates named *Synthetodus* do not show the characteristic structure of dipnoan dental plates. They lack the dipnoan radiating ridges or rows of tubercles. Their bilaterally symmetrical form, large central boss (or its equivalent, the tripartite division of the wearing area), are features strongly suggestive of certain shark pavement teeth, e. g., *Helodus*. And, for the present *Synthetodus* may, provisionally at least, be placed in the shark family Cochliodontidæ.

E 2017 An imperfect dental plate from the center of which rises a large smooth boss (Pl. 55, figs. 1, 2). The surface is highly polished and covered with a scattering of small punctæ. The under side is roughened with depressions and pustules.

Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Acmoniodus clarkei, n. gen., n. sp.

(Pl. 55, fig. 3; text-fig. 53)

One of the most peculiar fish remains in the collection is the specimen from the Conodont bed at Eighteen Mile Creek, represented in Plate 55, figure 3, and in text-figure 53. It is clearly a dental element,

[69] *Devonian fishes of Iowa*, 228–229, 1908.

but unlike any other known to us, and we describe it here as a new genus.

E 2575 *Type.*—A large dental plate (Pl. 55, fig. 3).

Formation and Locality.—Conodont bed (Lower Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

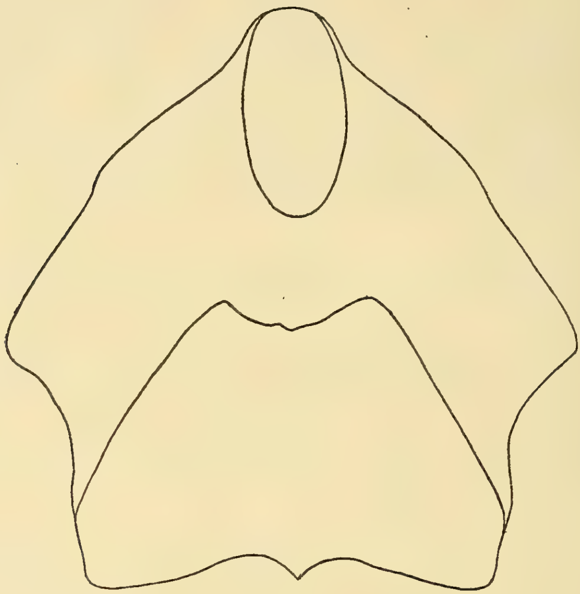

FIG. 53. *Acmoniodus clarkei,* n. gen., n. sp. OUTLINE OF TYPE SPECIMEN TO SHOW FORM OF THE ANTERIOR AND POSTERIOR TRITORS. (See Pl. 55, FIG. 3.) ×⅔. E 2575

A large, symmetrical dental plate, having the outline shown in figure 53; with two tritors in the median line, one at the anterior, or front end of the plate, the other occupying the posterior third of the element. Anterior tritor elliptical in outline, with the long diameter in the antero-posterior line of the element; not demarcated from rest of plate but merging gently into it; its upper surface covered with a shining, enamel-like substance and worn by use. On either side of posterior half of front tritor, a shallow depression in the bone, apparently produced by an upper apposing tritor. Posterior tritor shaped like the median-occipital of a dinichthyid, its anterior margin exca-

vated and shorter than posterior one; occupying about one-third the total area of the dental element.

Measurements:	*mm.*
Length, antero-posteriorly in middle line	112
Greatest width (estimated)	114
Length of anterior tritor	40
Width of anterior tritor	20

[*Akmonion*, a little anvil; *odous*, tooth.]

It gives us great pleasure to name this species for Dr. John M. Clarke, Director of the State Museum and of the Geological Survey of the State of New York.

Family ORODONTIDÆ

Orodus devonicus, n. sp.

(Pl. 44, fig. 4)

E 1903 *Type.*—A tooth, 16.5 mm. broad by 10 mm. long (i.e. antero-posterior diameter).

Formation and Locality.—Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, New York. Collected by W. L. Bryant.

Tooth small, its length (antero-posteriorly) about $\frac{2}{3}$ its width. Crown with three low, obtuse denticles, the middle one twice the size of the outer ones; lateral denticles directed forward and outward. Anterior faces of all denticles smooth; posterior and lateral faces covered with fine, raised lines which do not reach to the apices. No punctæ on denticles. Root of the usual orodont form, shelving backward from underneath the front margin of denticles and terminating posteriorly in a straight edge; thickest underneath posterior face of denticles.

Remarks.—Teeth of *Orodus* are common in the Carbonic, and especially abundant in the Lower Carbonic, but they are exceedingly rare in Devonic formations. In fact there is only a single species known from the Devonic—*Orodus elegantulus* Newberry—from the Cleveland shale of Ohio, and even this formation is regarded by some authors as of Waverlyan (Lower Carbonic) and not Devonic age. For this reason the present species from the Conodont bed, is of great

interest, as it proves beyond doubt that *Orodus* occurred in the Devonic; and that sharks with a grinding dentition suitable for feeding on hard food existed contemporaneously with the predaceous cladodont-toothed sharks,—*Cladoselache*, *Cladodus* and *Ctenacanthus*.

Orodus devonicus is distinguished from other American species by its low, obtuse denticles, by their style of ornamentation, and by the general proportions and symmetry of the tooth.

Family HETERODONTIDÆ
[Port Jackson Sharks]

Hybodus reticulatus Agassiz

E 2495 A large fin-spine, 29.5 cm. in length; maximum width, 3 mm. Liassic; Lyme Regis, England.

Family LAMNIDÆ
[Porbeagle, Mackerel and Great White Sharks]

Lamna gracilis Agassiz

E 2141 Three teeth. Eocene; S. Carolina.

Odontaspis cuspidata (Agassiz)

E 2142 Two teeth. Eocene; S. Carolina.

Isurus desorii (Agassiz)

E 2137 Three teeth. Eocene; S. Carolina.

E 2138 One tooth. Eocene; Florida. Ottomar Reinecke.

Isurus hastalis (Agassiz)

E 2134 Eight teeth. Eocene; Sienna, Italy.

E 2135 Two teeth. Eocene; S. Carolina.

E 2136 One tooth. Eocene; Florida, Ottomar Reinecke.

Carcharodon auriculatus (Blainville)

E 2133 Six teeth. Eocene; Ashley River, S. Carolina. Presented by Roswell H. Johnson.

Carcharodon megalodon Agassiz

E 2131 Thirteen teeth, the largest 15 cm. in height by 11.5 cm. in greatest width.
Eocene; Ashley River, S. Carolina.

E 2132 One tooth. Eocene; Sienna, Italy.

Family CARCHARINIDÆ
[Dusky Shark, Tiger Shark, etc.]

Galeocerdo lævissimus Cope

E 2144 One tooth. Miocene; Charles County, Maryland.

Hemipristis serra Agassiz

E 2139 Four teeth. Eocene; Ashley River, S. Carolina.

E 2140 Three teeth. Eocene; Phosphate beds, Western Florida. Presented by Ottomar Reinecke.

Family SPHYRNIDÆ
[Hammer-head Sharks]

Sphyrna magna Cope

E 2145 One tooth. Miocene; Charles County, Maryland.

Shark Vertebra

E 2146 Vertebral centrum. Eocene; Phosphate beds, Western part of Florida. Presented by Ottomar Reinecke.

Family PTYCHODONTIDÆ

Hemiptychodus mortoni (Mantell)

E 2127 Two teeth. Niobrara (Cretacic); Monument Station, Gove County, Kansas.

Family SQUATINIDÆ
[Monk or Angel Fishes]

Squatina alifera (Münster)

E 2162 Cast of a fish. Lithographic slate (Upper Jurassic); Eichstädt, Bavaria.

Squatina speciosa von Meyr

E 2161 Cast of the skeleton of a fish on a slab. Lithographic slate (Upper Jurassic); Eichstädt, Bavaria.

ICHTHYODORULITES

Acondylacanthus æquicostatus St. John and Worthen.

E 2500 Spine 150 mm. in length, lacking the inserted portion, and 11 mm. in extreme width. One of the lateral faces is imbedded in the limestone matrix, the other is exposed. The posterior face shows the deeply excavated pulp cavity, bordered by the double row of hooked denticles, which are present for a distance of 113 mm. below the apex. Each lateral face is ornamented by eleven smooth, polished costæ.

Keokuk limestone; Warsaw, Illinois? Purchased, 1915.

Anodontacanthus pusillus, n. sp.

(Pl. 44, fig. 2)

E 1915 *Type.*—A small spine lacking the distal extremity. Length 14 mm. (when complete about 20); greatest width 4 mm.

Formation and Locality.—Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Spine small, straight, gently tapering. Cross-section broadly elliptical toward proximal end, subcircular toward distal end. Pulp cavity completely enclosed, its diameter at proximal extremity of preserved portion one-fifth the diameter of the entire cross-section. External surface incised with longitudinal lines of various lengths, somewhat irregular in direction and occasionally anastomosing. No denticles.

Remarks.—The genus *Anodontacanthus* was established by J. W. Davis in 1881[70] for certain peculiar spines from the Coal Measures of England and Scotland, distinguished by (1) the absence of denticles from the posterior margin; (2) by their straight, tapering form; and (3) their subelliptical to subcircular cross section. A second species was described by Fritsch, in 1889,[71] from the Permian of Bohemia (under the name of *Platyacanthus ventricosus*), and a third by Hussakof, in 1911,[72] from the Permian of Texas. The genus, therefore, had a wide geographical as well as geological distribution. The present species is the first record of it from the Devonic.

These spines are probably head spines of Pleuracanth sharks, and it is not surprising therefore to find them represented in the Devonic, and particularly in the Conodont bed, since teeth of three species of Pleuracanth sharks (*Dittodus*) occur in this formation.

From the previously known species, the present one is distinguished by its very small size, by differences in cross-section, and by the ornamentation of incised lines, which are stronger and more irregular than in the other species, and by the absence of pittings in the striations.

Genus **Atopacanthus**, n. gen.

In 1913 Hussakof[73] described an ichthyodorulite remarkable for its very large denticles, or teeth, along one margin. The species did not fit into any known genus; and since all three specimens in hand were imperfect, it was thought inadvisable to base a new genus upon them. In view of the large size of the denticles and the thinness of the spine itself, the specimens were provisionally placed in the genus *Apateacanthus*, a genus known only by a unique spine from the Devonic of New York State—*A. vetustus* (Clarke).

Among the specimens from the Rhinestreet Shale in the Buffalo Museum, there is a spine of the same character; it throws a little light on these curious elements and enables us to frame a generic definition for them.

The specimen (fig. 54, *A*) is an elongated, spine-shaped element, narrowly elliptical in cross-section, with three teeth preserved along

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[70] On *Anodontacanthus*, a new genus of fossil fishes from the Coal Measures; with descriptions of three new species. *Quart. Journ. Geol. Soc.*, xxxvii ,427, pl. 22, figs. 10–12.

[71] Fritsch, A.: *Fauna der Gaskohle*, Band 3, p. 113, pl. 86, fig. 5.

[72] The Permian fishes of North America, in Case's "Amphibia and pisces of the Permian of North America." Publ. No. 146, Carnegie Institution Washington, p. 162, pl. 26, figs. 5, 5B.

[73] Hussakof, L.: Description of four new Paleozoic fishes from North America. *Bull. Amer. Mus. Nat. Hist.*, xxxii, 245–250, pl. xlvii, 1913.

one margin. The bone itself of the element is also present (not as in the three specimens mentioned above). The teeth are compressed cones, higher than the width of the supporting element, pointed, and compressed in the plane of the element. They bear a few striations in the basal half, somewhat like the teeth of *Holoptychius;* and one tooth that is broken across shows that they have a large pulp cavity.

Taken all in all, the specimen suggests a mandible or other jaw element with teeth, rather than a spine. But the element is narrower in proportion to the height of the teeth than in any mandible known to us. Perhaps it is comparable with such elements as *Edestus*, or the intermandibular series of teeth and their supporting bone in *Onychodus*. The present specimen seems to us to belong to a Teleostome, rather than a shark; and may have held a median, intermandibular position. This view finds some support in the fact that the teeth are striated, reminding one of Crossopterygian teeth. We propose the generic name *Atopacanthus* for this element (*atopos*, strange, odd, eccentric; *acantha*, spine, thorn).

The three elements referred to above as described by Hussakof in 1913 under the name *Apateacanthus peculiaris*, belong in the same genus, and should henceforth be known as *Atopacanthus peculiaris.*

Atopacanthus dentatus, n. gen., n. sp.

(Text-fig. 54, *A*)

E 2496 *Type.*—A fragmentary, narrow, compressed spine bearing three large teeth along one margin. Length, as far as preserved, 38 mm. (An additional 14 mm. is indicated by impression in the matrix.)

Formation and Locality.—Rhinestreet shale (Portage); forks of Eighteen Mile Creek, near Hamburg, N. Y. Collected by W. L. Bryant.

Body of spine, slender, bearing along one margin large, conical, compressed teeth, at right angles to the axis of the element. Undenticled margin not perfectly straight but with a few very slight convexities at short distances. Cross-section of element narrowly elliptical. Teeth relatively large, increasing progressively in size in the direction of the narrower end of the element; teeth with pulp cavity,

and the outer face striated. Height of largest of the three teeth preserved in type specimen greater than width of element in region of this tooth. Teeth well separated but distance between adjacent teeth less than width of one of the teeth. Spine ornamented with a few longitudinal striations (mostly worn off in the type specimen).

Remarks.—This species is distinguishable at a glance from *Apateacanthus vetustus* (Clarke), by the fact that the teeth are vertical instead of inclined. From *A. peculiaris* (Hussakof) the present species differs in the teeth being narrower in proportion to their height, and in being strongly striated. It is possible, however, that in the latter

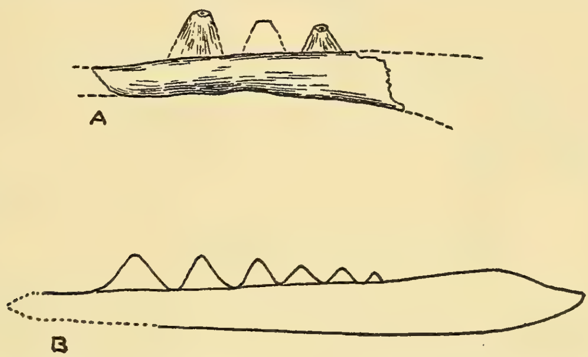

FIG. 54. A, *Atopacanthus dentatus*, n. gen., n. spec. TYPE, NATURAL SIZE. E 2496.
B, *Atopacanthus peculiaris* (Hussakof.) FOR COMPARISON; REVERSED RIGHT TO LEFT.

species, perfect specimens showing the external surface of the teeth, not merely their impression, would also show the teeth to have been striated.

Ctenacanthus nodocostatus, n. sp.

(Pl. 51, fig. 1)

E 2083 *Type.*—Impression in sandstone of a complete spine, 17 cm. in length.

Formation and Locality.—Yellow sandstone above "Second Mountain Sandstone" (Catskill); 4 miles South of Pleasantville, Venango County, Pa. Collected by J. F. Carll.

Spine of medium size, gently arcuate, with a large inserted portion, occupying about $\frac{1}{4}$ the entire length of the spine. Lateral faces orna-

mented with about 23 ridges, each composed of beads which are somewhat triangular in outline, with their apices directed downward, and generally, each apex covered by the base of the triangle below. The beading reduced or entirely absent from some ridges, particularly on the posterior half of the spine, where the ridges are almost smooth, and much finer than on the anterior part. Spaces between adjacent ridges, in middle part of spine, greater than width of a ridge. Line of demarcation between inserted and ornamented portions making an angle of 45 degrees with front margin of spine. Inserted portion with faint vertical striations and incisions. Posterior margin of each lateral face with a row of a small denticles directed somewhat downward.

Remarks.—This ctenacanth spine seems to be the first recorded from a Catskill horizon, if indeed the determination of the horizon in the old record be correct. The spine differs from all others by the peculiarities of the ornamentation referred to above, and may be recognized at a glance by the fact that the beading is absent entirely from some of the ridges and also from other spots on the spine, so that the smooth ridges and parts of ridges stand out clearly.

We have found one specimen with which the present one may be compared. This is the impression of the anterior half of a spine from the Hamilton, 1½ miles northeast of Pomeroy, Onondaga County, N. Y. (No. 874 Newb. Coll., Amer. Mus.) The specimen represents a spine considerably larger than the type. None the less, its style of ornamentation is so like that of the present species that we have no hesitation in referring it to it. *Ctenacanthus nodocostatus* therefore ranged from the Middle Devonic (Hamilton) to the top of the Devonic (Catskill). This imperfect specimen, in the Newberry collection, bears a label in Newberry's hand, reading *Ctenacanthus compressus* Newberry. It is obvious, however, on comparison of the specimen with the type of *C. compressus* and with another fine spine of the latter species, both in the Newberry collection, that the present spine is very different, and represents a distinct species. It appears probable that Newberry did not make a squeeze of the impression, but compared the impression directly, and this, superficially, resembles the ornamented face of *C. compressus*.

Ctenacanthus wrighti Newberry

(Pl. 52, fig. 2)

This species has hitherto been known only by the type specimen,[74] a large, well-preserved spine from the Hamilton (Mid. Devonic) of Yates County, N. Y. (No. 352 Newb. Coll., Amer. Mus.)

Several fragments of spines in the Buffalo Museum seem from their ornamentation to belong to this species. They are from the Conodont bed at Eighteen Mile Creek, N. Y., and were collected by W. L. Bryant. They thus extend the range of this species into the Genesee.

E 1904 Two fragments of spines with the ornamentation well preserved (Pl. 52, fig. 2). One of them agrees quite closely with the ornamentation of the type specimen.

E 2497 Fragment of a spine on a thin slab of rock together with numerous small fragments of Arthrodire plates, and several teeth.

Ctenacanthus sp.

E 2498 Fragment of a spine ornamented with rows of beads, each an elevated, transversely elongated tubercle with the upper margin smooth, somewhat beveled, the lower margin with strong pectinations; the whole bead resembling the form of a *Pecten* shell. This fragment probably represents a new species, but we do not wish to name it until a more or less complete spine, or at any rate a portion of a spine showing the size, form and number of ornamented ridges, is found.

Conodont bed (Genesee); Eighteen Mile Creek, near N. Evans, Erie County, N. Y. Collected by W. L. Bryant.

Cyrtacanthus dentatus? Newberry

(Text-fig. 55)

This species was based by Newberry on a spine of the kind now regarded as head spines, from their resemblance to the frontal claspers

[74] *N. Y. State Mus., 35th Rep.*, 1884, p. 206, pl. xvi, figs. 12–14; *Paleoz. Fishes, N. A.*, p. 66, pl. xxvi, figs. 4, 4a, 4b.

of Chimæroids. The type specimen is preserved in the American Museum, and so far as known, it is the only specimen of the species ever discovered.

FIG. 55. A, *Cyrtacanthus?* OUTLINE OF SPINE LABELED BY NEWBERRY: "*Cyrtacanthus dentatus?* N." NATURAL SIZE. E 1855

Onondaga limestone; Buffalo, N. Y.

55. **B,** *Cyrtacanthus dentatus* NEWBERRY. OUTLINE OF THE TYPE, NATURAL SIZE

Delaware limestone; Ohio. (Original in the Newberry Coll., Amer. Mus.)

E 1855 In the Buffalo Museum there is a portion of a spine (fig. 55, *A*) having some resemblance to the distal half of the type of *C. dentatus.* It was collected by Mr. F. K. Mixer, from the Onondaga limestone of Buffalo. The specimen was examined by Newberry, for it bears a label in his hand, reading, "*Cyrtacanthus dentatus*? *N*. *Cyrtacanthus* is probably one arm of a forked spine belonging

to Agassiz's genus *Cladacanthus*." For comparison, an outline figure of the type of *Cyrtacanthus dentatus* (fig. 55, *B*) is given side by side with that of the present specimen.

The Buffalo specimen undoubtedly has a resemblance to Newberry's type, but it cannot be unreservedly regarded as of that species. The denticles on the incurved margin are absent, although one or two blunt protuberances suggest weathered denticles; and the outer surface near the distal extremity is not ornamented with tubercles as in the type. But on the whole the spine is more like the distal end of the type of *C. dentatus* than any other ichthyodorulite, and it is best to leave it in that species as was done by Newberry. Additional material illustrating the species is much to be desired.

As regards the affinities of *Cyrtacanthus:* it represents either a head spine, as stated above, or an unpaired spine placed in the median line of the fish. Newberry thought, as expressed in his note on the label of the Buffalo specimen, that *Cyrtacanchus* is probably one arm of the spine known as *Cladacanthus*. If we bear in mind that *Cladacanthus* is a synonym for *Erismacanthus*, this opinion is about all that one may express even at the present time; for *Cyrtacanthus* undoubtedly belongs in the group of head or median spines which includes *Erismacanthus*, *Harpacanthus* and allied forms.

Edestus minor Newberry

E 2153 Cast of a series of six teeth, attached to their supporting element.

Coal Measures: Indiana. (History of specimen unknown.)

Genus **Gamphacanthus** S. A. Miller[75]

Heteracanthus, J. S. Newberry, Paleoz. Fishes N. Amer., 66, 1889, [preoccupied]. *Gamphacanthus*, S. A. Miller, First Appendix [to N. Amer. Geol. and Pal.] 715, 1892.

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[75] In a paper published after the above was already in the hands of the printers, Eastman (*Proc. U. S. Nat. Mus.*, vol. 52, p. 244, 1917) employs the name *Heteracanthus* for *Gamphacanthus*. There seems to us no valid reason for doing so. *Heteracanthus* is clearly preoccupied. This was shown as long ago as 1892, by S. A. Miller, who proposed *Gamphacanthus* to replace it, which name was accepted by O. P. Hay in his *Bibl. and Cat. Fos. Vert. N. Amer.*, 1902 (p. 332). The fact that the relationship of these spines is at present unknown and they must be placed under the head of Ichthyodorulites, does not affect the matter of the name. If a generic name is applied it is amenable to the rule of priority.

We note also that Eastman refers these spines to Chimæroids—on the ground of their occurrence in the same formation with Ptyctodonts (which latter he considers to be Chimæroids). Unfortunately for this view, there are no fin-spines, nor indeed any skeletal or dermal elements similar to the *Gamphacanthus* spines in any Chimæroid.

This genus is known by two species, *G. politus* Newberry, and *G. uddeni* Lindahl, both from the American Devonic. The former ranges through the Hamilton and into the Portage; the latter is known only from the Hamilton. It is not clear to what group of fishes these spines pertain. The suggestion has been made by Eastman[76] that they may belong to Ptyctodonts, since they are frequently found in the same beds with ptyctodont and rhynchodont dental plates; however, beyond the fact of contemporaneity, there is no evidence for this view. Newberry[77] has remarked on the resemblance between these spines and those known as *Physonemus* and *Stethacanthus*.

Gamphacanthus uddeni (Lindahl)

(Pl. 52, fig. 1)

This species is represented by three specimens, one of them (E 1875) a nearly perfect spine (Pl. 52, fig. 1). This agrees closely with the type figured by Lindahl, except that it seems somewhat more compressed, a circumstance perhaps due to the mode of preservation.

There has been some vagueness about the distinctions between *Gamphacanthus uddeni* and the type species, *G. politus*. We have therefore compared two of the specimens of the former (E 1875 and E 1877) with the cotypes of *G. politus* Newb. (Amer. Mus. Coll.). *G. uddeni* as compared with *G. politus* is (1) more compressed, as shown by cross-sections of both the distal and proximal halves of the spine; (2) has a larger number of striations, especially in the proximal half; (3) the crenulations of the incised lines on the distal half are much less conspicuous and in some specimens entirely absent.

The three specimens in the Buffalo Museum are from the Hamilton (Mid. Devonic) of Milwaukee, Wis. Collected and presented by Mr. E. E. Teller, of Buffalo.

E 1875 Nearly complete spine, in matrix, (Pl. 52, fig. 1). Length, 112 mm.; greatest width (at 2 cm. from proximal margin), 33.

E 1876 Proximal half of spine, uncrushed and showing dimensions of pulp cavity.

E 1877 Proximal two-thirds of a spine somewhat larger than E 1875, in matrix. No sinuosities whatever are to be seen along

[76] Devonian Fishes of Iowa. *Iowa Geol. Survey*, xviii, 139, 1908.
[77] *Paleozoic Fishes of North America*, 66, 1889.

the incised lines. This specimen confirms the impression derived from E 1875, that the species is somewhat more compressed than appears from Lindahl's figure of the type specimen.

FIG. 56. CROSS-SECTIONS OF *Machæracanthus major*
A, section of distal third of spine; *B*, section at about middle.

Machæracanthus major Newberry

(Pl. 53, figs. 1, 2; text-fig. 56, *A*, *B*)

This genus persisted in western New York beyond the Mid Devonic, since it ranges into the Conodont bed (Genesee). It is represented in the collection by a number of specimens.

Specimens of Machæracanthus are always found with one side embedded in matrix, and as their knife-like lateral edges make it impossible to extricate them without damage, no specimen has to our knowledge ever been completely extricated from the matrix so as to allow of study from both sides. Furthermore, few specimens show the distal extremity in perfect preservation. One of our specimens, E 1848 (Pl. 53, fig. 2), consisting of the distal half of a large spine, shows this portion to be of rather different conformation than is usual in *M. major*, and it seems to us probable that the specimen represents the under side of the spine, whereas other specimens that have been figured represent the upper. This is of course only a supposition, which cannot be established unless a complete spine of *M. major* were extricated from the matrix, or one were sectioned at several levels, which, however, would destroy the spine as a specimen.

E 1847 Impression of an imperfect spine. Length, 140 mm.; greatest width, 25.

Onondaga limestone, (Mid. Devonic); Park Quarry, Buffalo, New York. Collected by Mr. F. K. Mixer.

E 1848 Distal half of a spine (Pl. 53, fig. 2). Length, as far as preserved, 95 mm.; greatest width, 21. This is the specimen referred to above as showing the opposite side to that already known in *Machæracanthus.* As will be seen from the figure, the median ridge, instead of extending to the point of the spine, terminates about 2 cm. from the extremity, at which point the ridge and the lateral alæ merge into a smooth, rounded surface. As this ridge is not sharp-angled, but broad and rounded, it is obviously the ridge on the opposite side to the one usually figured; and so gives for the first time information as to the form of the distal extremity of this side of the spine.

Onondaga limestone (Mid. Devonic); Cemetery Quarry, Buffalo, New York. Piper collection.

E 1849 Distal half of a spine. Length, as far as preserved, 92 mm.; width (at 55 mm. from apex), 21. This specimen agrees well with typical spines of this species. (Pl. 53, fig. 1.)

Onondaga limestone; Cemetery Quarry, Buffalo, New York. Collected by Mr. F. K. Mixer.

Machæracanthus longævus Eastman

Machæracanthus longævus Eastman, New York State Mus., Mem. x, 85, plate ii, fig. 8, 1907.

E 1874 *Type.*—Right and left pectoral fin-spines of one fish, imperfectly preserved; in counterpart.

Lower Hamilton (so-called "Trilobite bed"); shore of Lake Erie, near mouth of Eighteen Mile Creek, N. Y.

The original description of the specimen by Eastman,[78] may here be quoted.

The present example is interesting in that it is one of the few in which spines of both pectoral fins are preserved in natural association. That this is the case, instead of there being merely a single, large broken spine, is evident from the similar proportions and general appearance of the two spines, one of which clearly represents the proximal and middle portions, and the other a section extending

[78] Devonic fishes of the New York formations. *N. Y. State Mus., Mem. x,* 85–86, 1907.

from about the middle for a considerable distance beyond in the direction of the apex. The form of the cross-section leaves no doubt that both spines present the same aspect, presumably the outer or external face. On the opposite, or internal face, the median carina appears to be gently rounded throughout its entire length. One of the distinguishing characteristics of this species, however, is that the axial ridge on the side which is presumed to be external remains sharply triangular only in the distal half of the spine, becoming widened into a broad flat elevation, smooth or but faintly striated, and nearly rectangular in cross-section, toward the base of the spine. The general surface is smooth, save for the usual delicate striæ, slightly convergent toward the apex, and possibly of the same nature as growth lines.

The foregoing description is, however, incorrect in one particular. The spines do not both present the same aspect. It is plain from the conformation of the median ridges and from the curvature of the two spines as they appear side by side, that one presents the inner, and the other the outer aspect. The median ridge of one is triangular in cross-section, while in the other it is flat.

The following specimen from the Conodont bed apparently also belongs to this species. If the determination is correct it extends the range of the species from the Lower Hamilton (Mid. Devonic) into the Lower Genesee (U. Devonic).

E 1906 Fragment of a spine having a cross-section somewhat similar to that of *M. longævus*.

Machæracanthus peracutus Newberry

(Pl. 53, fig. 3)

The following specimens, which are smaller and more slender than examples of *M. major* probably belong to *M. peracutus* Newberry.

E 1850 Distal half of spine, in matrix. (Pl. 53, fig. 3).
Onondaga limestone; Cemetery Quarry, Buffalo, New York. Collected by Mr. F. K. Mixer.

E 1851 Incomplete spine.
Onondaga limestone; Cement Quarry, Buffalo, New York. Collected by Mr. F. K. Mixer.

E 1852 Spine of a young individual. In the smaller spines of this species, the longitudinal axis of what we here call the under side, is relatively higher than in those of adults. Other data same as preceding.

E 1853 Fragment of a spine.
Onondaga limestone; Park Quarry, Buffalo, New York. Collected by Mr. F. K. Mixer.

E 1854 Fragment of a spine.
Onondaga limestone; Cement Quarry, Buffalo, New York. Piper collection.

Machæracanthus sp.

(Pl. 53, fig. 4)

In addition to the specifically determinable spines described above, there are in the Buffalo Museum a number of spine fragments collected by Mr. Bryant in the Conodont bed, which are rather more slender than is usual in spines of this genus. They are most like those of *M. peracutus*, but may represent a distinct species.

E 2514 Distal third of a spine drawn out to a much more slender point than in any species of *Machæracanthus* of which the complete spine is known; in matrix (Pl. 53, fig. 4). Length, as far as preserved, 57 mm.; greatest width, 13. The spine possibly appears so slender through the thin lateral alæ having been broken away before the specimen became embedded in sediment.

E 2515 Distal end of a spine; the lateral alæ restored in plaster.

Onchus rectus Eastman

E 2591 Spine measuring 3.5 cm. as far as preserved. The distal extremity is lacking and the proximal half of the inserted portion is represented only by the impression. The spine when complete measured not more than 4.5 cm. It agrees in every character with Eastman's description of this rare species, hitherto known only by two specimens from the Chemung of Delaware County, N. Y.
Limestone layer at the horizon of the "Third oil sand" (Chemung group), Erie, Pa. Collected by Mr. E. J. Armstrong.

Stethacanthus præcursor, n. sp.

(Pl. 54, figs. 1, 1a, 2)

E 1908 *Cotypes.*—Two nearly complete spines.
(1) The more perfect specimen of the two; length, 82 mm. (Pl. 54, fig. 2). It shows the apex of the spine, the hump (somewhat injured) and the region behind it.

E 1909 (2) This spine lacks the apex, and the two faces are crushed together in the hump region; but it shows the inferior margin of the front half of the spine. Length, as far as preserved, 78 mm.

Formation and Locality.—Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Spine about 9 cm. in length; depth at beginning of hump contained about 3 times, and the part of spine behind hump about $3\frac{1}{2}$ times, in the total length. Hump in profile view, gently convex above, and descending to meet the post-hump portion of spine in a slight sigmoid curve; hump, viewed from above, relatively broad (its posterior margin is not sufficiently preserved to show its entire outline); its height less than the portion of the spine back of it. Upper margin of spine gently concave, changing to gently convex toward the apex; "lower" margin of apex almost straight. Sides of spine incised with short, irregular lines and shallow grooves more or less parallel to the axis of spine.

Remark.—This species is known only by the two cotypes. These are complete spines, but not well-preserved; between the two, however, the characters of the species may be fully made out. Plate 54, figure 1, is a composite drawing based on the two specimens.

The species is readily distinguished by the relatively straight apical portion, which is not reflexed upward as in most species (for instance, *S. altonensis*); and by the form of the hump, as well as its relative size as compared with the post-hump portion of the spine.

If we compare the present species with *Stethacanthus* spines from later horizons, we are perhaps justified in regarding it as primitive or generalized. This is shown by the fact that the apical portion of the spine is straight, not recurved; in later forms this portion is gently

reflexed upward so as to produce a deep excavation between hump and apex. In fact, in some of the later spines, for instance, the small species *S. erectus* Eastman, and *S. exilis* Hussakof, both from the Waverly, this is carried to an extreme, the apical axis being at right angles to the hump.

Stethacanthus depressus (St. John & Worthen)

(Pl. 54, fig. 3)

E 2516 Impression of a small spine in sandstone; also a squeeze of same in dental wax.

The specimen, though small, is complete and shows well the characters of the species.[79] Length 30 mm. (apex missing); height at posterior border of hump, 8 mm.

Top layer of "Second Mountain Sandstone" (Catskill); Crawford County, Pa., Carll collection.

Ichthyodorulite, indet.

E 1907 A thin, fragmentary spine, or plate, with serrated edges, and a rounded central axis which gives it somewhat the appearance of a fragment of a *Machæracanthus* spine. Perhaps an Arthrodire plate.

DIPNEUSTI

Dipterus gemmatus, n. sp.

(Pl. 56, figs. 2, 2a)

E 2517 *Type.*—A small dental plate on a piece of limestone.

Formation and Locality.—Conodont bed (Genesee); Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Dental plate small, about 13 mm. in length (antero-posterior diameter), its greatest width about two-thirds its length. Ridges, five or six, tuberculated, radiating from a smooth central area which

[79] The specimen figured by Eastman in *Bull. Mus. Compar. Zool.*, xxxix, 216, fig. 15, as *Stethacanthus depressus*, is incorrectly referred to this species.

occupies over one-third the length of the plate (at the middle ridge). Outermost denticles of each ridge rounded, succeeding ones somewhat compressed, and in the principal ridge tending to fuse into a compressed edge. Number of denticles in principal ridge, two or three; in second ridge, three; in third, four; in fourth, five. In the third and succeeding ridges the outermost denticles are more or less discrete, i. e., not confluent at their bases. All denticles, as well as interspaces between them, covered with minute punctæ.

Remarks.—This species is closest to *Dipterus flabelliformis* Newberry, and *D. pectinatus* Eastman. It is distinguished by the much larger smooth, central area; by having fewer ridges, and in each ridge fewer and more discrete denticles. In the third longest ridge of *D. flabelliformis* there are nine or ten denticles, whereas in the third ridge of the present species there are only four.

Dipterus valenciennesi Sedg. & Murchison

E 2518 A fine head-shield, 5 cm. in length, showing prettily all the head plates and the sensory canals.
Old Red Sandstone; Weydate, Thurso, Scotland.

Dipterus nelsoni (Newberry)

E 2519 Right mandibular dental plate. Chemung conglomerate? N. W. Pa. Collected by J. F. Carll.

Dipterus sp.

E 2015 A small dental plate, in matrix (Pl. 56, fig. 1). Conodont bed; Eighteen Mile Creek, near North Evans, Erie County, N. Y. Collected by W. L. Bryant.

Scaumenacia curta (Whiteaves)

(Pl. 57, figs. 3, 4; text-fig. 57)

This is now one of the best known of Devonian lungfishes, the exquisitely preserved specimens found in the Scaumenac Bay region of Canada having afforded a knowledge of every detail of its external structure. A restoration of this form has been published by Hussakof[80] (text-fig. 57).

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[80] Hussakof, L.: Notes on Devonic fishes from Scaumenac Bay. *N. Y. State Museum, Bull. 159*, p. 135, 1912.

In the Buffalo Museum there are a number of fine specimens of this species, collected by Mr. Bryant at the type locality, the Upper Devonian shales on Scaumenac Bay, near the village of Megouasha, Quebec, in August, 1915.

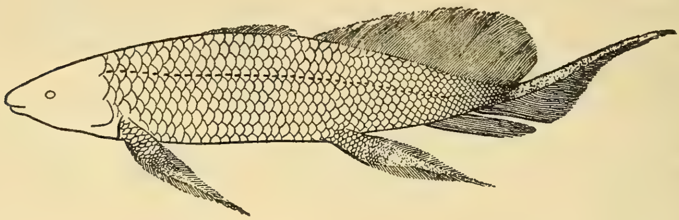

FIG. 57. RESTORATION OF *Scaumenacia curta* (Whiteaves). UPPER DEVONIC SCAUMENAC BAY, QUEBEC. AFTER HUSSAKOF.

E 2521 A small fish, 15 cm. in length, shown in side view. It exhibits the head and all the fins. The head is imperfectly preserved but shows beautifully the posterior half, represented by the impression of the upper surface. The palatines are moved from their natural position, but show in oral view. The most interesting thing about the specimen is that the entire upper dentition, consisting of both dipterine as well as both vomerine plates, is preserved. The dipterine plates are broken but agree in their general characters with the description of these plates given by other authors. The vomerines are stout, and somewhat compressed. One, which is perfectly preserved, has two cusps or serrations; the other, two and the "root" of a third. Each cusp is sculptured by a broad, shallow furrow on the outer face. (Pl. 57, fig. 3.)

The discovery of a specimen of *Scaumenacia* showing the vomerine teeth is of very great interest. Another such specimen was described by Hussakof in 1912;[81] and in the same year Dr. William Patten[82] published restorations of *Scaumenacia* in which so-called premaxillaries are indicated. Watson and Day[83] have suggested that

[81] Hussakof, L.: Notes on Devonic fishes from Scaumenac Bay, Quebec; *N. Y. State Mus. Bull.* *158*, pp. 127, 139; 3 plates, 1912.

[82] Patten, W.: The Evolution of the vertebrates and their kin. Philadelphia. P. 386, fig. 261–F; p. 389, fig. 264, 1912.

[83] Watson, D. M. S. and Day, Henry: Notes on some Palæozoic fishes. *Mem. & Proc. Manchester Lit. & Phil. Soc.*, lx, p. 33, 1916.

the teeth figured by Hussakof might represent the premaxillaries. However, the specimen found by Mr. Bryant seems to indicate that these teeth are true vomerines.

In the specimen previously described, the vomerines had respectively four and five cusps. In the present one there are two and three. This indicates that the number of cusps or serrations was not constant, but varied in different individuals, and probably also with age. "In view of this serrated condition the vomerines of *Scaumenacia* may be regarded as more primitive than those of the adult *Neoceratodus*. They resemble somewhat the vomerines of the embryonic *Neoceratodus* as described by Semon."[84] (Hussakof, *loc. cit.*, page 137.)

E 2520 A large fish lacking the head, but showing all the fins and the lateral line in great perfection. The body is not so distorted as in most small specimens of this species. In the same matrix is the impression of a dorsal shield of *Bothriolepis*.

E 2522 Crushed head, shown from above, and displaying dentition.

E 2523 Small fish lacking head; in counterpart. It shows nearly a complete series of neural and haemal spines, the cleithrum and other details. Length 10.5 cm.

E 2524 Fish, in counterpart, showing the head; dorsal, caudal and anal fins; also the eye, jaws, scale ornamentation, calcified neural and haemal spines, and fin supports. Length 11 cm.

E 2525 Small fish, showing both dorsals, the anal and caudal fins also haemal spines and the lateral line. Length 11.5 cm.

E 2526 Fish lacking head, but showing both dorsals, the anal and part of the caudal. Length 12 cm.

E 2527 Fish, in counterpart, showing the second dorsal, caudal, and anal fins; also the cleithrum, and the lateral line. Head crushed. Length 16.5 cm.

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[84] Semon, R.: Die Zahnentwickelung des *Ceratodus forsteri*. *Zool. Forsch. in Austral. u. Malay Archipel.*, 115–135, pl. xviii–xx, 1899.

E 2528 Small fish, showing lateral line, cleithrum and other details Length 9 cm.

Dipnoan Scale

E 2545 A large punctate scale, 4.5 by 3.5 cm. (broken), perhaps belonging to a dipnoan.

Catskill; Seeley Creek, branch of Lambs Creek, near Mansfield, Tioga County, Pa. Collected by W. L. Bryant, 1913.

[The type of *Dipterus sherwoodi* was found in this locality.]

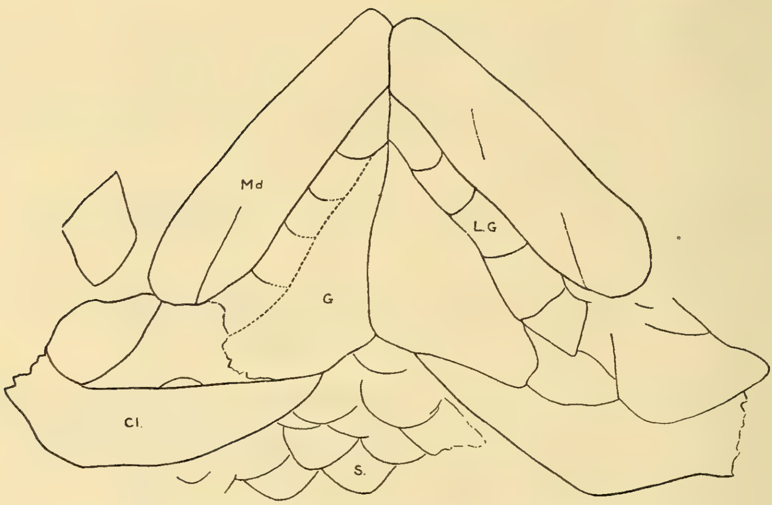

FIG. 58. *Holoptychius quebecensis* (Whiteaves). GULAR REGION. × ABOUT ½ *Cl*, cleithrum; *G*, gular; *L.G*, series of lateral gulars; *Md*, mandible; *S*, scales. E 2529.

CROSSOPTERYGII

Family HOLOPTYCHIIDÆ

Holoptychius quebecensis (Whiteaves)

(Text-fig. 58)

This species is still imperfectly known, owing to the fact that specimens of it are usually much broken or fragmentary. In the Buffalo Museum there are two specimens that show the throat region with the

principal and lateral gulars in position. This part of the anatomy is of course known in other species of the genus, e.g., from the Old Red Sandstone of Scotland.

E 2529 Gular region of a large fish (fig. 58). It shows the principal and lateral gulars very prettily, and on the outside of these, the mandibles. Most of the bone is gone but the impressions of the plates are clearly indicated. The lower parts of both cleithra are preserved. Between their extremities and back of the principal gulars are a number of imbricating scales. Preserved fragments of the bone of both the principal and the lateral gulars, show that these plates were ornamented with small, crowded tubercles which were not coalesced into lines. The scales immediately back of the gulars are for the most part ornamented with tubercles, which in some scales are more or less coalesced into lines.

Upper Devonic; Scaumenac Bay, near Village of Megouasha, Quebec. Collected by W. L. Bryant. August, 1915.

E 2530 Gular region of a smaller fish than the preceding. Both the principal and lateral gulars are shown, the bone being present and viewed from the inner or visceral aspect. The arrangement is very similar to that of the preceding specimen. There are five or more lateral gulars on either side.

Holoptychius americanus Leidy

E 2151 Cast of a large scale.

Chemung; Tioga County, Pa.

E 2544 Impression of scales.

Catskill; Seeley Creek, branch of Lambs Creek, Mansfield, Tioga County, Pa.; collected by W. L. Bryant.

Holoptychius giganteus Agassiz

E 2531 Scales, fin-rays and a head plate (?). Length of scale 22 mm.; width, 25 mm.

Other data same as preceding.

Holoptychius halli Newberry

E 2532 Impression of a scale; length, 2 cm.; width, 1–5 cm. Catskill ? Northern Pennsylvania—exact locality unknown; collected by J. F. Carll. [The type of the species comes from the Catskill at Delhi, N. Y.]

Holoptychius cf. **nobilissimus** Agassiz

E 2533 Cast of a scale. Length, 55 mm.; width, 45 mm. (broken). It has the reticulated ornament of *H. nobilissimus*, but was apparently as large as *H. giganteus*. Original in Philadelphia Acad. of Nat. Sci.

Mansfield ore bed (Upper Chemung); Tioga County, Pa.

Holoptychius serrulatus ? Cope

E 2534 Impression of a scale and fin-rays. (Compare Smith Woodward, *Cat. Fos. Fishes Brit. Mus.*, II, pl. xi, figs. 1c, 1d; Cope, *Proc. Am. Phil. Soc.*, vol. 36, pl. ii, fig. 1.[85]

The tubercles of the covered area seem to be completely fused into ridges. Resembles *H. serrulatus* Cope, but is smaller and lacks the cone-like tubercles of the covered portion. It may, however, be a caudal scale of this species as it came from the same formation and locality as *H. serrulatus* Cope.

Catskill; Seeley Creek, branch of Lambs Creek, Mansfield, Tioga County, Pa.; collected by W. L. Bryant.

Family RHIZODONTIDÆ

Eusthenopteron foordi Whiteaves
(Pl. 70, fig. 2)

Of this well-known species there are a number of excellent specimens in the Buffalo Museum, collected at the type locality, the Upper Devonic of Scaumenac Bay, Quebec, by Mr. W. L. Bryant, in August, 1915.

[85] The figures in this paper are wrongly numbered: Figure 1 is *H. serrulatus*: Figure 2, *H. flabellatus*: Figure 3, *H. latus*.

E 2535 Head of a large fish, little crushed, and showing clearly the plates of the roof and the right side of the cranium, including the mandible and gular plates; eye and lateral lines well shown. In addition to these features, the fossil shows portion of a pectoral fin with its supports and the ornamented squamation of the fore part of the trunk. Length, 16 cm.

E 2536 Complete fish with all fins. The head is bent backward upon the body, showing its inferior aspect.

E 2537 Posterior half of fish showing anal, second dorsal and caudal fins.

E 2538 Fish, in counterpart, showing dentition. Fins imperfectly preserved.

E 2539 Crushed head of small fish, showing gular plate, jaws and roofing bones, in inner view.

E 2540 Tail of a large fish.

E 2541 Fish lacking head but showing outline of body, all fins, lateral line and operculum.

E 2546 Fragments. Anterior portion of fish with a few head plates and the pectoral fin.

E 2547 Fragment of cranium, showing supratemporal bones from the inside.

E 2548 Portion of trunk of fish, showing vertebral centra.

E 2549 Pair of mandibles of a small fish. The laniary teeth are shown, some of them fractured, affording a longitudinal view of the pulp cavity.

E 2550 Scales of trunk.

E 2551 Weathered specimen showing disarticulated head plates and jaws.

E 2552 Posterior half of a very young fish, showing outlines of body, both dorsals, the ventral, anal, and caudal fins; in counterpart.

E 2553 Fragmentary head of large individual, in counterpart, showing mandible, maxilla, suborbital and the gular plates.

E 2554 Nearly complete fish so twisted as to show lateral view of trunk and tail, and inner aspect of cranium; the sutures of the cranium have opened so as to show the outlines of the component plates. Body is somewhat macerated, but the pectoral, ventral and caudal fins are preserved.

E 2555 Side and top view of a crushed cranium, together with a fragment of the pectoral fin. Roofing bones and jaws well shown.

E 2594 Pectoral region of large fish, showing squamation, and an excellently preserved pectoral fin with its supports (Pl. 70, fig. 2).

Family ONYCHODONTIDÆ

Genus **Onychodus** Newberry

A genus of Crossopterygii known only by detached head plates, jaw elements, teeth and scales. Its most remarkable feature is the presymphyseal bone with its semicircle of teeth. Three American species have been described, all from the Devonic; but of these two seem to be synonymous—*O. sigmoides* and *O. hopkinsi.* The latter was based on somewhat smaller and less curved teeth than *O. sigmoides,* but the materials now in various museums show that some teeth from the *hopkinsi* locality are fully as large and as much curved as any *sigmoides* teeth.

Onychodus sigmoides Newberry[86]

(Pl. 58; text-fig. 59)

Onychodus sigmoides Newberry, Proc. Nat. Inst., n. ser. 1, 124, 1857.
Onychodus hopkinsi Newberry, Ibid., 124, 1857.

This species is represented in the collection by a number of plates and teeth. Of special interest are the remains from the Conodont

[86] For full synonymy see Hay, *Bibliography and Catalog Fossil Vert. N. A.*, 1902, p. 363.

bed, at Eighteen Mile Creek, for they demonstrate that this typically Onondagan species ranged into the Genesee. This is not surprising, since remains of *Onychodus* have been recorded from the Chemung. The surprising thing is—if all these remains really belong to a single species—that *Onychodus sigmoides* should be represented both in fresh (Chemung) and in salt water (Conodont and Onondaga limestone).

The mandible of *Onychodus* described below is of unusual interest, since it affords for the first time a knowledge of the structure of this element in the genus. The specimen (Pl. 58, fig. 3 and text-fig. 59) consists of about two-thirds of a left mandible; it lacks the anterior, or symphyseal end, as well as the posterior extremity. The upper margin is set with slender, sharply-pointed laniary teeth placed at wide intervals, and not all of the same size. Some of them had apparently

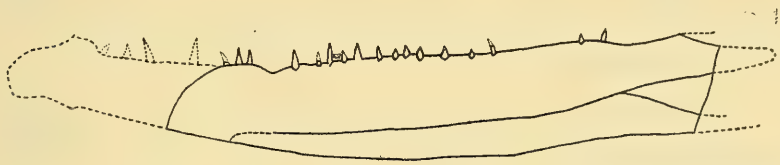

FIG. 59. *Onychodus sigmoides* Newberry. RESTORED OUTLINE OF MANDIBLE SHOWN IN Plate 58, FIGURE 3

All the elements composing it are shown—the *dentary* above, *angular* below, and the *articular*, at the extreme right, wedged in between these two. The front end of the mandible is restored after a specimen from the Delaware limestone of Ohio. Onondaga Limestone; Leroy, N. Y. E 2556.

become worn through use, or else had been broken off before preservation. The mandible clearly indicates the presence of several distinct elements; first, a dentary element (*den.*), a narrow element in which the teeth are set, extending the entire length of the preserved portion of the mandible. Second, an angular (*ang.*), situated below the dentary, and extending forward about two-thirds the length of the mandible. Third, an articular element (*art.*); the bone itself is absent in the specimen, but its position is clearly indicated by the sutural lines and facets on the angular and dentary. It was wedged in anteriorly between these two elements.

It has been customary in describing the mandibles of the *Crossopterygii*, to refer to all the elements below the dentary, as *infradentaries*, except the most posterior one, which has generally been called

angular.[87] But the demonstration in recent years that the *Crossopterygii* are ancestral to the Tetrapoda, necessarily changed this point of view, and the Crossopterygian mandible is now regarded as possessing elements homologous with those of primitive amphibia. This conclusion rests on the cumulative work of Smith Woodward, Broom, Williston, Gregory and Watson. Broom[88] in a special paper on the subject, in 1913, showed that in the mandible of the Crossopterygian *Sauripterus taylori*, from the Chemung of Pennsylvania, the infradentaries represent the elements found in the typical Stegocephalian mandible, for instance, *Trimerorachis*, and that they may be interpreted as splenial, preangular, angular, surangular, prearticular and articular. So, too, in the latest paper on the subject, by W. K. Gregory,[89] this is the view advocated. And it is in line with this newer interpretation that the elements in the mandible of *Onychodus* are named above. Our specimen does not show the front portion of the mandible, so that the splenial, if present in *Onychodus*, is not shown. And at the posterior end, the surangular is not preserved.

1. Specimens from the Delaware limestone (Mid. Devonic); Delaware, Ohio.

E 1871 A series of six premandibular teeth with their supporting symphyseal bone. The teeth are curved, as is usual in these specimens (Pl. 58, fig. 2).

E 1872 A series of symphyseal teeth, and their supporting bone. One tooth shifted from its position.

This and the following specimen were presented by Mr. E. E. Teller.

E 1873 A detached tooth, 4 cm. in height. (Pl. 58, fig. 1)

2. Specimens from the Onondaga limestone at Leroy, N. Y.

E 2556 The fine mandible discussed in the preceding pages and illustrated in Plate 58, figures 3, 3a, 3b, and text-fig. 59.

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[87] See for instance the excellent figure of the mandible of *Rhizodus hibberti* in Smith Woodward's *Catalog of Fossil Fishes*, Part II, pl. xii, fig. 1.

[88] Broom, R.: On the structure of the mandible of Stegocephalia *Anat. Anz.*, xlv, 77–78.

[89] Gregory, W. K.: Present status of the problem of the origin of the Tetrapoda with special reference to the skull and paired limbs. *Annals N. Y. Acad. Sci.*, xxvi, 317–383, pl. iv, 1915. See especially p. 334 for table of homologies between bones of mandible in Rhipidistia and Stegocephali, and for references to the work of Smith Woodward, Williston, Broom, and Watson, on which these conclusions rest.

It is rather small and is apparently not of a full-grown fish.
Collected and presented by Prof. Clifton J. Sarle.

E 2564 A large tooth, 30 mm. in height (imperfect).
Collected and presented by Prof. Clifton J. Sarle.

3. Specimens from the Conodont bed (basal Genesee) at Eighteen Mile Creek, near N. Evans, Erie County, N. Y.

E 2557 An imperfect presymphyseal tooth, in matrix, shown in longitudinal section. The tooth is 43 mm. in height, and the pulp cavity extends to within 6 mm. of the tip. The wall of the tooth is slightly over 1.5 mm. in thickness

E 2563 A mandibular tooth, 40 mm. high.

Family CŒLACANTHIDÆ

Cœlacanthus elegans Newberry

E 2090 Imperfect fish on coal.
Coal Measures; Linton (now Yellow Creek), Jefferson County, Ohio.
Presented by J. S. Newberry.

E 2091 Caudal extremity of a fish on coal.
Other data same as preceding.

ACTINOPTERYGII

Family PALÆONISCIDÆ

Cheirolepis canadensis Whiteaves

(Pl. 57, figs. 1, 2)

E 2558 Tail, showing ornamented scales and fin-rays
Upper Devonic; Scaumenac Bay, near village of Megouasha, Quebec. Collected by W. L. Bryant, August, 1915.

Genus **Rhadinichthys** Traquair

In the Portage rocks in the vicinity of Buffalo occur scales, cranial plates and incomplete fishes, which apparently belong in the palæ-

oniscid genus, *Rhadinichthys.* They have been described as three distinct species:

1. *Rhadinichthys devonicus.*—J. M. Clarke; Bull. 16, U. S. Geol. Surv., p. 41, Plate i, figures 2–6, [as *Palæoniscum*]. 1885.
2. *Rhadinichthys antiquus.*—H. U. Williams; Bull. Buffalo Soc. Nat. Sci., v, p. 84, figure 2. [as *Palæoniscum*]. 1886.
3. *Rhadinichthys reticulatus.*—H. U. Williams; Ibid., p. 86, figure 1. 1886.

Of these three names the last seems to be a synonym of the first; so that only two species may properly be recognized, distinguished from each other by details of ornamentation of the scales and cranial plates.

Rhadinichthys devonicus (Clarke)

(Pls. 59, 60, 61, 62; 63, figs. 1, 2; 65; text-figs. 60, 61)

In 1885 John M. Clarke described an imperfect fish and a number of isolated scales and cranial plates under the name of *Palæoniscum devonicum.* The specimens were collected in a "railroad cutting through the bituminous layers in the town of Sparta"—a Portage horizon. In the following year H. U. Williams described and figured a number of isolated scales and cranial elements from the Portage near Buffalo, which he placed in two new species, *Palæoniscum reticulatus* and *P. antiquus.* It seems to us on careful comparison of his figures of *P. reticulatus* with the figures and description given by Clarke of *P. devonicus,* that these names refer to the same species.

The following is Dr. Clarke's account of this species:

One individual retains most of the body in place, though the bones of the head have been displaced and scattered, and the tail is somewhat crushed. The animal was originally about 13 cm. in length. The cranial bones, ... are characteristically marked by punctate incised lines which run along the greatest diameter of the bone, occasionally [as in his figure 5] radiating from the most convex portion of the plate. . . . . Associated with these bones are many minute, shining, somewhat flattened, conical teeth, measuring 0.75 mm. in length. The scales, except those on the dorsal ridge, are 1.5 mm. long and 5 mm. wide, subrhomboidal in outline and very beautifully sculptured with strong elevated striæ, which take their origin at the upper forward angle and pass obliquely across the scale, the forward edge presenting the appearance of being strongly tucked. These elevated striæ become very much stronger at the posterior edge, and in this region, the upper portion of the scale being left free of striæ, shows strong punctate markings. These pittings are also to be seen in the furrows between the striæ on the anterior portions of the scale.

The median dorsal scales are large, spatulate in form, measuring 3.5 mm. in width anteriorly, and narrowing backwards to 1.5 mm.; length 4 mm. Surface strongly punctate.—J. M. Clark, "On the higher Devonian faunas of Ontario County, New York, *Bull. 16, U. S. Geol. Surv.*, 1885, p. 41.

If we compare the figures given by Clarke and by Williams (the latter reproduced here as fig. 60), we find a very close correspondence. Thus, Williams' figure 1*d*, might almost have been drawn from the

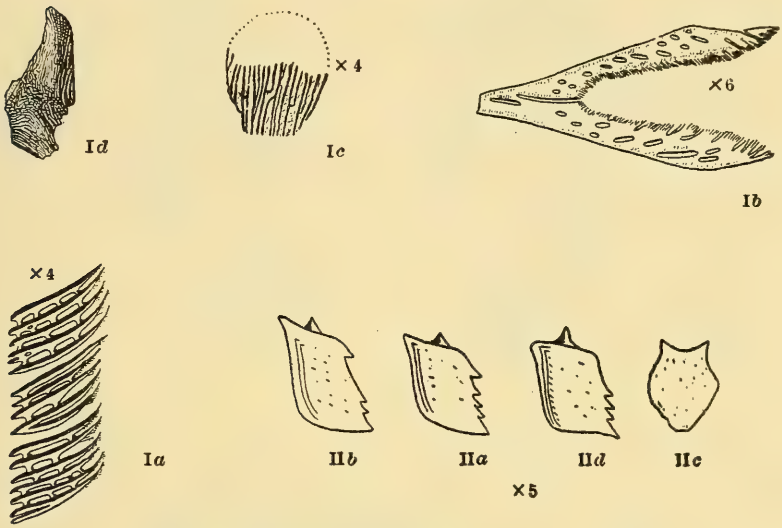

FIG. 60. BONES AND SCALES OF *Rhadinichthys*, ENLARGED. (AFTER H. U. WILLIAMS)

I *a–d*, *Rhadinichthys devonicus* (Clarke). I *a*, flank scales; I *b*, fulcral scale; I *c*, fragment of bone showing ornamentation of reticulated lines; I *d*, cranial plate showing ornamentation.

II *a–d*, *Rhadinichthys antiquus* (Williams). II *a*, *b*, *d*, flank scales, showing peg for articulation; II *c*, ridge scale.

cleithrum of *Palæoniscus devonicus*, figured (as a cranial plate) by Clarke in his Plate i, figure 5; while Williams' figure 1*c*, of a cranial plate, agrees fairly well with Clarke's figure 6. Both these latter show a cranial plate ornamented with more or less parallel lines anastomosing in places. Williams' figure of the scales, 1*a*, agrees with Clarke's figure 3, except that in Clarke's figure the punctæ are not so clearly shown.

It thus seems to us that the forms described by Clarke and by Williams from isolated scales and plates, represent a single species; and for this Clarke's specific name, *devonicus*, has priority.

This species is represented in the Buffalo museum by a considerable series of scales, cranial plates, fulcra, etc., preserved singly or in groups, on small pieces of shale. All are from the Rhinestreet shale (Portage), on the shore of Lake Erie, near Sturgeon Point, N. Y.

E 2044 Imperfect fish, showing outline of body and caudal extremity (Pl. 59). This and the following five numbers collected by Mr. F. K. Mixer.

E 2045 Cranial plates including the frontal and the operculum; detached scales and a number of elongated fin-rays. Some of the plates show the sensory canals (Pl. 60, fig. 3).

E 2046 Parietal? plate.

E 2047 Operculum. (Pl. 60, fig. 2; text-fig. 61, B.)

E 2048 Left cleithrum. (Pl. 60, fig. 1; text-fig. 61, A.)

E 2049 Cranial plates, scales and fin-rays of a single individual. (Pl. 62, fig. 4; Pl. 63, figs. 1, 2.)

E 2050 Right maxilla. (Pl. 61, fig. 3.) This and the following specimens collected by Mr. W. L. Bryant.

E 2051 Right maxilla. (Pl. 61, fig. 1.)

E 2052 Right maxilla.

E 2054 Left maxilla.

E 2053 Right cleithrum.

E 2055 Left mandible. (Pl. 62, fig. 1.)

E 2056 Mandible showing teeth in two series.

E 2057 Mandible? lacking teeth.

E 2058 Mandible, lacking teeth.

E 2059 Mandible, lacking teeth.

E 2060 Mandible, lacking teeth.

E 2061 Detached scales. (Pl. 62, figs. 2, 3.)

E 2062 Cranium, shown in inner view.

E 2063 Cranial plate (post-temporal?), shown in inner view.

E 2064 Supraclavicle?

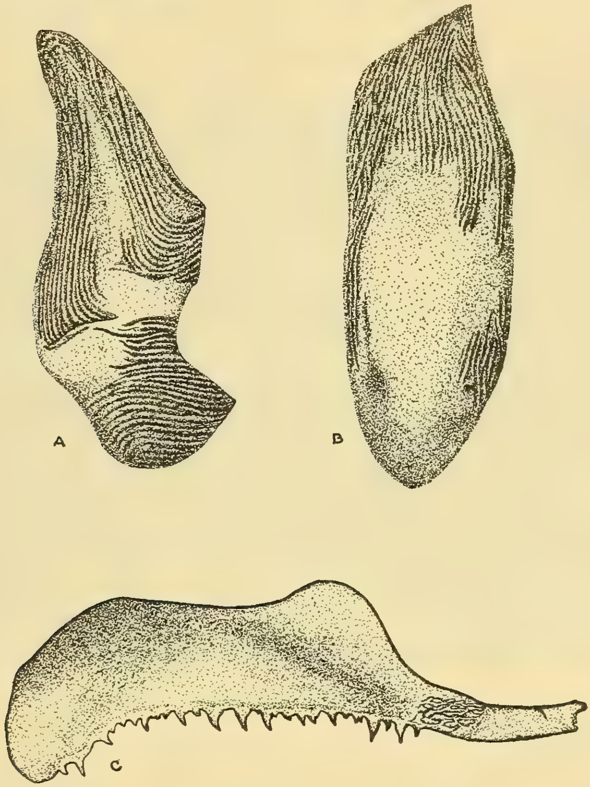

FIG. 61. *Rhadinichthys devonicus* (Clarke). × 3

A, cleithrum; E 2048. Drawn from specimen shown in Plate 60, figure 1. **B,** operculum; E 2047. Drawn from specimen shown in Plate 60, figure 2. **C,** right maxilla, outer view, but with almost entire surface ornament lost; E 2067. Plate 61, figure 2.

E 2066 Right maxilla, with teeth. (Pl. 65, fig. 2.)

E 2067 Right maxilla, with teeth. (Pl. 61, fig. 2; text-fig. 61, C.)
F. K. Mixer, coll.

Rhadinichthys devonicus? (Clarke)

(Pl. 65, figs. 1, 3)

Several isolated plates in the collection, from the Cleveland shales of Ohio, bear an ornamentation very similar to that of plates of *Rhadinichthys devonicus* from the Portage of Western New York, and it appears probable that they belong to the same species. They are of about the same size as the latter, and so far as can be made out from their imperfect preservation, they have the same outlines as the corresponding plates of the Western New York form. In Plate 65, figure 1, a maxilla from the Cleveland shale is shown, for comparison, near a maxilla of *Rhadinichthys devonicus* (E 2066) from the Portage near Buffalo.

E 2565 A right maxilla, on a piece of shale, displaying ornamentation and greater part of outline of the element. (Pl. 65, fig. 1).
Cleveland shale (Upper Devonic); Linndale, near Cleveland, Ohio. Collected by W. L. Bryant.

E 2566 Both mandibles, separated from each other, and displaying the outer, ornamented surface. Teeth are to be seen in both mandibles, but cannot be clearly made out. (Pl. 65, fig. 3.)
Other data same as preceding.

Rhadinichthys antiquus (Williams)

(Pl. 63, fig. 3; Pl. 64; text-fig. 62)

The following specimens in the collection are all from the Rhinestreet shale (Portage), on the shore of Lake Erie, near Sturgeon Point, N. Y.

E 2065 Imperfect fish, showing head, trunk and caudal fin; the dorsal, anal, and paired fins are missing. (Pl. 63, fig. 3; text-fig. 62.) Collected by Mr. F. K. Mixer.

E 2068 Left cleithrum. (Pl. 64, fig. 1.) This and the following specimens collected by Mr. W. L. Bryant.

E 2069 Left cleithrum.

E 2070 Imperfect left cleithrum.

E 2071 Impression of right cleithrum.

E 2072 Cranial plate.

E 2073 Detached scales.

E 2074 Detached scales. (Pl. 64, figs. 2, 4, 5, 6.)

E 2075 Detached scales.

FIG. 62. *Rhadinichthys antiquus* (Williams). POSTERIOR HALF OF FISH, SHOWING HETEROCERCAL TAIL, AND THE FULCRA OF ITS UPPER AND LOWER LOBES. NATURAL SIZE. E 2065

Rhadinichtys ? indet.

E 2076–7 That another species of Palæoniscid in addition to tne two preceding inhabited the waters of what is now Western New York during Portage time, is indicated by two specimens in the collection—a cleithrum and a cranial plate, whose external faces are ornamented by a series of crenulated ridges, arranged transversely to the long diameter of the bone.

Rhinestreet shale (Portage); shore of Lake Erie, near Sturgeon Point, Erie County, N. Y. Collected by W. L. Bryant.

Rhadinichthys alberti (Jackson)

(Text-fig. 63)

This is the best known American species of *Rhadinichthys*, and extensively represented in museums. For a full account of it, with a restoration and admirable figures of scale detail, reference should be made to the memoir of L. M. Lambe, "Palæoniscid fishes from the Albert shales of New Brunswick,"[90] published in 1910.

The following specimens are in the Buffalo museum. They are from the type locality, the Albert Mine (Lower Carbonic), Albert County, New Brunswick. Carll collection.

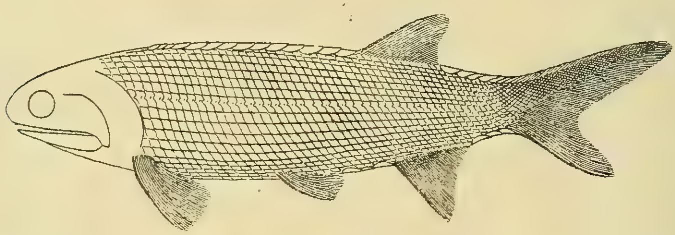

FIG. 63. RESTORATION OF *Rhadinichthys alberti* (Jackson). AFTER LAMBE

E 2112 Imperfect fish on a piece of shale.

E 2113 Imperfect fish.

E 2114 Imperfect fish.

E 2115 Imperfect fish.

E 2116 Imperfect fish.

E 2117 Imperfect fish, showing caudal fulcra; also detached flank and ridge scales.

E 2120 Detached flank and ridge scales.

[90] *Contributions to Canadian Pal.*, vol. iii, Mem. 3, pp. 1–68, pls. i–xi.

Rhadinichthys elegantulus (Eastman)

(Pl. 66; text-fig. 64)

Elonichthys elegantulus EASTMAN, Rept. Geol. Surv. Iowa, xviii, 274. 1908.
Elonichthys elegantulus L. M. LAMBE, Contrib. to Canadian Pal., iii, Mem. 3, p. 30. 1910.

In 1908 Eastman gave the name *Elonichthys elegantulus* to a small palæoniscid found associated with *Rhadinichthys alberti* in the Lower Carboniferous of Albert County, New Brunswick. In 1910, Lambe

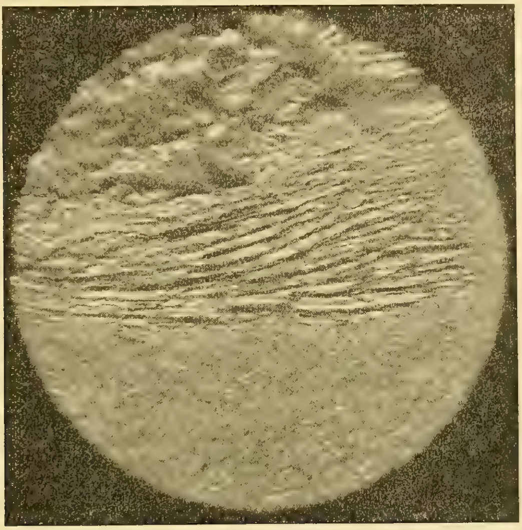

FIG. 64. *Rhadinichthys elegantulus* (Eastman). PECTORAL FIN, ENLARGED. E 2094

discussed some of the characters of the species and expressed doubt as to its validity. He writes:

"Its small size, in conjunction with its generally imperfect state of preservation, leads one to suspect that it may be the young of one of the species already known from this locality, possibly of *R. alberti*. Of the many scores of specimens in our collections, nearly all lack proper definition of outline, and the head is, as a rule, very imperfectly preserved."[91]

In the Buffalo museum there are a number of specimens of this

[91] Loc. cit., p. 30.

species which were collected by the late John F. Carll. They have enabled us to draw up the following diagnosis.

Revised description.—A species of small size, about 45 mm. in length. Greatest depth of body just behind the pectoral arch, the trunk tapering rapidly backward from this point.

Dorsal and anal fins almost opposite, large, triangular, longer than high, with rays which branch distally. Caudal strongly heterocercal, the upper lobe being nearly twice the lower, the fin-rays slender, and distally branching; pectoral fins moderately large, their principal rays unarticulated; provided with minute, slender fulcra; ventral fins short-based and about equidistant from pectoral and anal. Lateral line present.

From the above emended description it appears that this species belongs to the genus *Rhadinichthys* rather than to *Elonichthys*, to which we accordingly assign it.

E 2092 Complete fish, 45 mm. in length, showing head and all fins. (Pl. 66, figs. 1, 2.)

E 2093 Imperfect fish, showing well the anal and dorsal fins. (Pl. 66, fig. 3.)

E 2094 Complete fish, showing head in ventro-lateral aspect; pectoral, pelvic and anal fins. (Fig. 64.)

E 2095 Small slab with the remains of several fishes. One specimen in lateral aspect shows detail of all fins.

E 2096 Slab with several fragmentary fishes showing cranial bones and pectoral fins. On same slab is a scale of *Rhadinichthys alberti* (Jackson).

E 2097 Imperfect fishes on small slab.

E 2098 Imperfect fishes on small slab.

E 2099 Cranium, shown in inner view.

E 2100 Imperfect fish.

E 2101 Imperfect fish.

E 2102 Imperfect fish.

E 2103 Imperfect fish.

E 2104 Imperfect fishes on small slab. They show position of dorsal and anal fins.

E 2105 Imperfect fish.

E 2106 Imperfect fish; shows mandible and maxilla in position.

E 2107 Imperfect fish; shows the cranial bones

E 2108 Imperfect fish.

E 2109 Imperfect fish.

E 2110 Imperfect fish.

E 2121 Fish showing head and all fins.

Elonichthys browni (Jackson)

This species was recently restudied by Lambe,[92] who published an extended account of it together with splendid figures of complete fishes and of details of the scales. It is the largest of the palæoniscids found in the Albert Mine, New Brunswick, the fishes ranging in size, according to Lambe, from 18.5 to 35.5 cm.

E 2111 Detached scales from posterior portion of trunk.
Lower Carboniferous; Albert County, New Brunswick. Carll collection.

Haplolepis [Eurylepis] tuberculata (Newberry)

E 2088 Small complete fish on coal.
Coal Measures; Linton (now Yellow Creek), Jefferson County, Ohio. Presented by J. S. Newberry.

Haplolepis [Eurylepis] granulata (Newberry)

E 2089 Small complete fish on coal. There is some doubt whether this species is distinct from the preceding; in fact, all the species of *Haplolepis* are in need of revision. Other data same as preceding.

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[92] Lambe, L. M.: Palæoniscid fishes from the Albert shales of New Brunswick. *Contrib. Canadian Palæont.*, iii, 22, pls. iv–ix, 1910.

Family CATOPTERIDÆ

Catopterus gracilis J. H. Redfield

E 2125 Fish with all fins.
Newark series (Triassic); Boonton, N. J. Presented by J. S. Newberry.

Catopterus redfieldi Egerton

E 2124 Nearly complete fish. On the same slab is a nearly complete fish of *Semionotus fultus*.
Other data same as preceding.

Genus **Dictyopyge** Egerton

This genus is closely related to *Catopterus*, differing chiefly in the more forward position of the dorsal fin, which begins a little in front of the anal. The genus is widely distributed, being known by eight or nine species, occuring in North America, Europe, Australia, and probably also in South Africa.

Dictyopyge macrura (W. C. Redfield)

(Pl. 24, fig. 3; Pl. 67)

This is one of the rarest of North American fossil ganoids, known by only one or two complete specimens and a number of fragments. Until recently the type specimen had been lost, but it was lately found by Dr. A. S. Woodward; it had been in use as a paper weight in one of the offices in the British Museum.

Dictyopyge macrura is known from only one locality—the Upper Triassic shales, near Richmond, Va. Eastman[93] has referred to a specimen in the Museum of Comparative Zoology at Cambridge, Mass., (No. 2531), which is labelled "probably from Middletown, Connecticut," and has accepted it as evidence of the occurrence of the species in the Triassic of the Connecticut Valley. But to us this specimen does not seem to afford conclusive evidence of the occurrence of the species in Connecticut. The fact that the label reads "probably," indicates that it was not written by the hand that collected the specimens; or if so, only after so long an interval since it was collected,

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[93] Eastman, C. R.: Triassic fishes of Connecticut. *Bull. No.* 18, *State Geol. and Nat. Hist. Survey*, Connecticut, p. 56, 1911.

that the circumstances were hazy in the writer's mind; and in fact he may have confused his specimen with some other. Obviously the label cannot carry conviction. Furthermore, among the various collections of fishes from the Connecticut Valley Trias there is not a single specimen of *Dictyopyge*, notwithstanding that hundreds of specimens have been collected. Although this fact, being mere negative evidence would not in itself be conclusive, still it lends force to the argument that the label on the specimen is probably incorrect. In any event, there is no positive proof at present that *Dictyopyge* occurs anywhere else but in the Richmond, Va. locality.

We may note that at the time Newberry[94] studied this species, specimens were abundant at the type locality, and numbers were frequently found on one slab, as in the case of specimens of *Semionotus* from the Karoo formation of South Africa. Newberry mentions a slab which "though scarcely more than a foot square, carried impressions of over forty individuals."[95]

The Buffalo Museum is fortunate in possessing a slab of shale containing remains of ten fishes, two or three of them almost complete (Pl. 67). From a study of this specimen we are able to give a revised description of the species.

Revised description.—Fish gracefully fusiform, attaining a length of 15 cm. Head contained five times, and greatest depth six times in the total length. Dorsal originating in advance of anal; triangular, about ½ the size of anal. Anal the largest of all the fins, arising opposite middle of dorsal and extending beyond beginning of caudal; with about 25 broad, robust articulated rays; its posterior margin rounded, not straight. Caudal heterocercal, with about 35 rays; its upper lobe fringed with about 50 small fulcra giving the margin a braided appearance. Pectoral relatively small. Ventral with 10 to 12 robust rays anteriorly margined with minute fulcra. Cranial bones ornamented with scale-like confluent tubercles and irregular intersecting ridges (Pl. 24, fig. 3). Scales smooth and highly polished. Lateral line prominent.

The single specimen in the collection may be described as follows:

E 2126 A slab of shale 25 by 17 cm., containing the remains of 10 fishes, two of them more or less complete, (Pl. 67).
Triassic coal beds; Richmond, Va. The specimen was

[94] Newberry, J. S.: Fossil fishes and fossil plants of the Triassic rocks of New Jersey and the Connecticut Valley. *Monograph U. S. Geol. Surv.*, xiv, 64, 1888.
[95] Loc. cit. p. 65.

collected many years ago by Mr. David F. Day, who presented it to the Museum.

Family LEPIDOTIDÆ

Lepidotus maximus Wagner

E 2154 Cast of a portion of the trunk of a large fish, showing scales.
Lithographic slate (Upper Jurassic); Solnhofen, Bavaria.

E 2156 Cast of a large fish, showing dentition and fins. Lithographic slate (Upper Jurassic); Solnhofen, Bavaria.

Lepidotus minor Agassiz

E 2160 Cast of a large fish, shown in side view; all the fins are present, and the head is fairly well shown.
Upper Oolite; Isle of Portland, England.

Family SEMIONOTIDÆ

Semionotus fultus (Agassiz)

E 2122 Fish with all the fins.
Newark series (Triassic); Boonton, N. J. Presented by J. S. Newberry.

Semionotus tenuiceps (Agassiz)

E 2123 Nearly complete fish.
Other data same as preceding.

Family PYCNODONTIDÆ

Gyrodus circularis Agassiz

E 2155 Cast of a fish, showing the cranium, facial bones, dental apparatus and all the fins.
Lithographic slate (Upper Jurassic); Solnhofen, Bavaria.

Microdon elegans Agassiz

E 2159 Cast of a fish, showing all the fins.
Upper Jurassic; Kelheim, Bavaria.

Family ASPIDORHYNCHIDÆ

Aspidorhynchus acutirostris (Blainville)

E 2567 Fish lacking head and caudal extremity. Length as far as preserved, 40 cm.; greatest depth of body, 6.5.
Lithographic slate (Upper Jurassic); Solnhofen, Bavaria.

E 2158 Cast of a fish, shown in side view.
Lithographic slate (Upper Jurassic); Eichstädt, Bavaria.

Family LEPISOSTEIDÆ

Lepisosteus simplex Leidy

(Pl. 68)

Although a dozen species of fossil gar pikes have been named from various localities in North America,[96] only three are known by complete fishes; the others are represented by vertebræ, scales or head plates, and are not satisfactorily defined. The species represented by whole fishes are:

1. *Lepisosteus atrox* Leidy—Green River shales (Eocene), Wyo.
2. *Lepisosteus simplex* Leidy—Green River shales (Eocene), Wyo.
3. *Lepisosteus* (Clastes) *cuneatus* (Cope)—Miocene, Utah.

Of these, the best represented species is *L. simplex*, known by at least three splendid specimens—one in the United States National Museum,[97] a second from the Eocene of Utah,[98] and a third, undescribed, in the American Museum. To these three we may now add a fourth specimen—a splendid fish which even surpasses the preceding ones in size, preserved in the Buffalo Museum. It is from the type locality, the Green River shales of Wyoming. We base the identification of the species chiefly on the character of the fins, which

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[96] Hay, *Bibliography and catalog fos. Vert. N. Amer.*, p. 377.

[97] Eastman, C. R.: Fossil Lepidosteids from the Green River Shales of Wyoming. *Bull. Comp. Zool.* xxxvi, 74, pl. i, fig. i, 1900.

[98] Briefly described by Prof. T. D. A. Cockerell in *Science*, n. s., xxix, 796, 1909.

are rather weaker than in *L. atrox*, and upon the ornamentation of the scales. These appear perfectly smooth to the naked eye, except for one, or sometimes two, large punctæ near their centres, while under a lens the entire surface is seen to be covered with minute pittings.

The fossil was obtained some years ago from a track hand, in Wyoming, by the late Dr. Ernest Wende, formerly a director of the Buffalo Society of Natural Sciences; it later became the property of the Society through the kindness of Mrs. Wende.

E 2150 A gar pike 88 cm. in length, on a slab of shale (Pl. 68). The fish is shown in lateral view, except the head, which rests on its dorsal surface, displaying the inside of the cranium. All the fins are shown—more beautifully, in fact, than in any other specimen hitherto known. The left pectoral is shown above the right, and the same is also the disposition of the ventrals.

In the head, the left maxilla is detached and lies above its mate, with its large laniary teeth overlapping the mandible—as seen near the bottom of the figure. The vomer, palatines, and parasphenoid are very little disturbed. The facial bones are badly crushed, but both cleithra are preserved. Little can be said as to the external ornamentation of the head plates, except that the outer surface of the left cleithrum seems to be covered with fine, oblique striations. The mandibles and maxillæ each bear a double series of teeth, and the vomer and palatines are covered with short conical teeth.

The longest vertebral centrum exposed (above base of ventral fin), measures 1.2 cm. in length.

The pectoral fin has 9 rays, and shows a series of slender fulcra. The ventrals are nearer the anal than the pectoral, have 5 rays, and are armed with biserial fulcra. The anal has 8 or 9 rays, the dorsal 7. The latter begins about opposite the origin of the anal. The caudal, which is completely preserved, is rounded posteriorly, and has 15 rays. The fulcra of its upper margin are slender, and apparently in a single series; those of the lower margin are robust and biserial.

The ornamentation of the scales has already been referred to above. The squamation is much disturbed

in the front half of the fish, exposing to view the vertebral centra and ribs; while in the posterior part of the fish the scales are hardly disarranged. There are at least 50 transverse rows of scales in the length of the fish.

Measurements	*cm.*
Total length (including caudal)	88
Depth, behind pectoral arch	15
Length of head	26
Length of pectoral	8
Length of ventral	10
Length of anal	10
Length of dorsal	10
Length of caudal	12
Length of mandible	16

Family AMIIDÆ

Megalurus elegantissimus Wagner

E 2157 Cast of a fish 11 cm. in length, showing all the fins.
Lithographic slate (Upper Jurassic); Solnhofen, Bavaria.

Family PHOLIDOPHORIDÆ

Pholidophorus sp.

E 2599 Head and anterior portion of trunk.
Lithographic stone; Solnhofen, Bavaria.

Family CLUPEIDÆ

Diplomystus brevissimus (Blainville)

This species is represented by three specimens, collected by Mrs. C. B. Hoyt. They are from the type locality and formation—Upper Cretaceous; Mt. Lebanon, Syria.

E 2128 Slab of limestone with four finely-preserved fishes.

E 2129 Slab with four fishes.

E 2130 Complete fish on limestone, showing all fins.

Knightia [Diplomystus] humilus (Leidy)[99]

E 2149 Small fish on a piece of shale.
Green River shales (Eocene); Wyoming.

Family OSTEOGLOSSIDÆ

Phareodus testis (Cope)

E 2147 Complete fish with well-preserved head, showing teeth and with all fins. Total length, 33 cm.
Green River shales, (Eocene); Twin Creek, Wyoming.

E 2148 Head of a large fish with finely preserved teeth.
Formation and locality same as preceding. Collected by Dr. Ernest Wende.

Family BERYCIDÆ

Hoplopteryx superbus (Dixon)

E 2163 Cast showing five fishes on a slab.
Cretaceous; Lewes, England.

Coprolites

E 2118 and **E 2119** Two Coprolites.
Lower Carboniferous; Albert County, New Brunswick. Carll collection.

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[99] We follow D. S. Jordan, who proposed *Knightia* as a generic name for a section of *Diplomystus*, with *Diplomystus humilus* Leidy, as the type species. *Univ. California Publ. Bull. Dept. Geol.* No 5 p. 136, 1907.

PLATES

PLATE 1

Restoration of the head and dorsal armor of *Dinichthys magnificus*, n. sp., viewed from in front. $\times \frac{1}{5}$. Type specimen. See p. 36. (Mounted for exhibition by W. L. Bryant.)

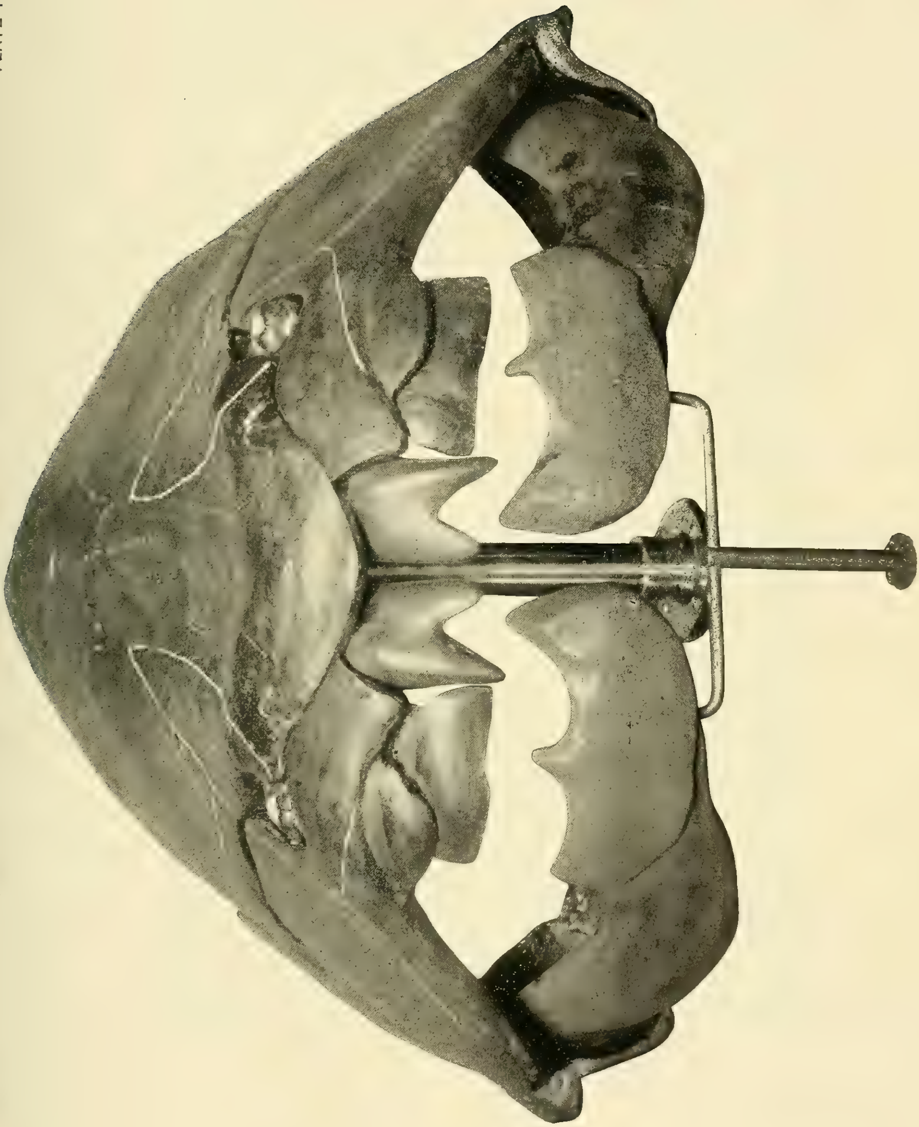


PLATE 2

Section on Eighteen Mile Creek, showing exposure of the Genesee and lower portion of the Portage. The Conodont bed is absent in this section.

A,	Cashaqua shale	Portage
B,	Middlesex shale	
C,	West River shale	Genesee
D,	Genundewa limestone	
E,	Genesee shale	

(See text-fig. 2)

A
B
C
D
E

PLATE 3

Upper: Lower part of a section on Eighteen Mile Creek where the Conodont bed is best developed.

A, West River shale
B, Genundewa limestone
C, Conodont bed
D, Genesee shale
(See text-fig. 2)

Lower: Section at same level as the above but a few hundred feet away, showing absence of the Conodont bed. (This is an enlarged view of the lower part of section shown in Plate 2, immediately to the left of the camera box seen in that picture.)

A, West River shale
B, Genundewa limestone
D, Genesee shale


A
B
C
D


A
B
D

PLATE 4

Figs. 1, 2, 3. *Coccostus parvulus*, n. sp. · Cotypes, about natural size. The specimens are impressions in shale, and the figures are from squeezes made from them. Originals of 1 and 3 are on one slab. Page 29.

1. Two cranial plates, showing the tuberculated ornamentation. E 2371.
2. Postero-medianventral, showing outer, ornamented face. E 2372.
3. Median occipital, in inner, or visceral view. E 2371.

Fig. 4. *Coccosteus* sp. Postero-ventromedian, in inner view; about natural size. E 2377, p. 31.

Fig. 5. *Coccosteus* sp. Postero-ventromedian, in outer view. $\times \frac{3}{4}$. E 2376, p. 31.

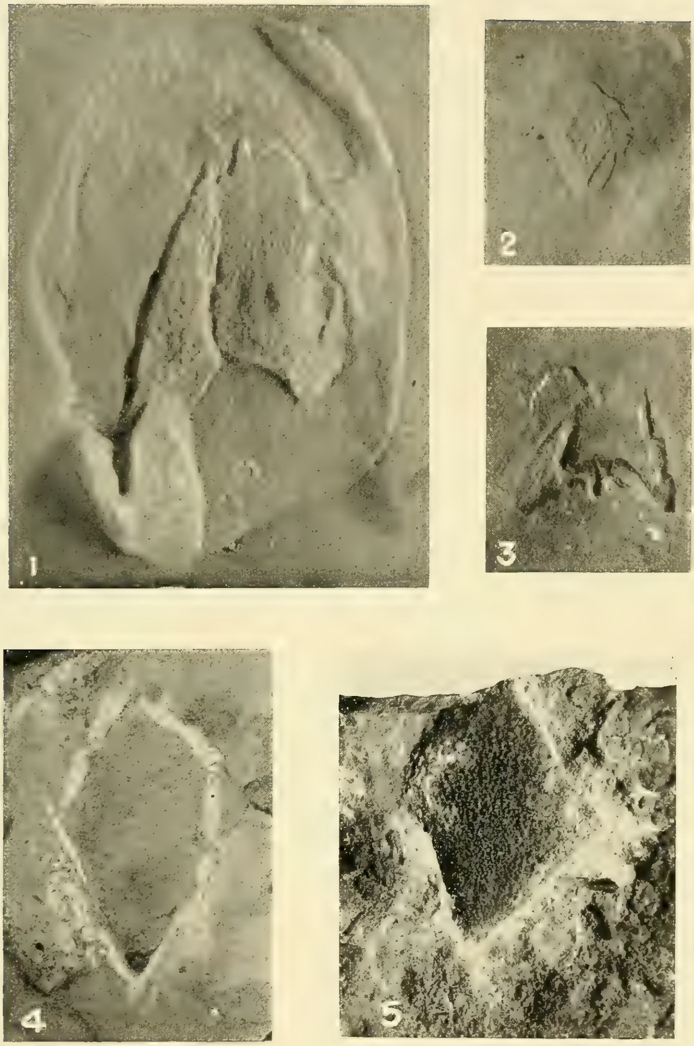

1
2
3
4
5

PLATE 5

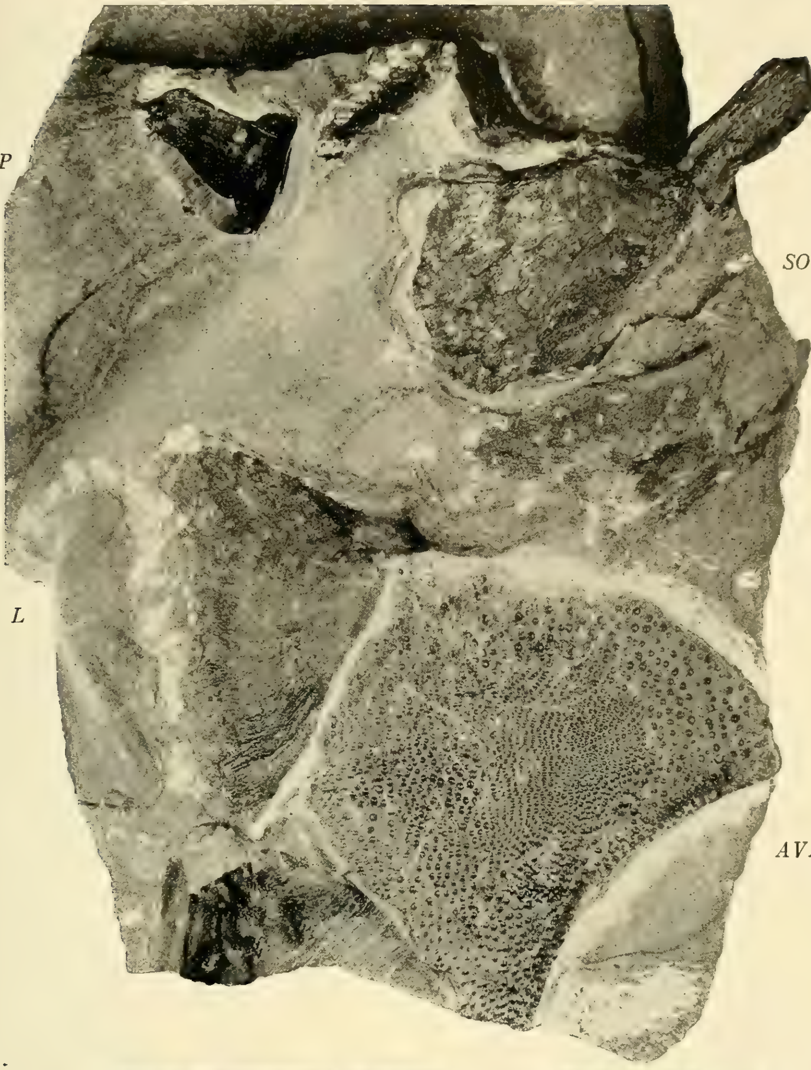
Coccosteus canadensis Woodward

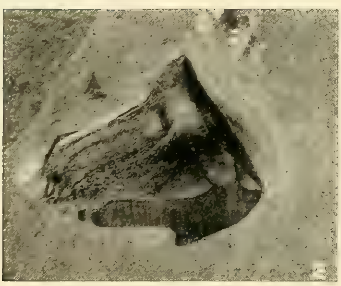
Upper Devonic; Scaumenac Bay, Quebec, Canada

Fig. 1. Plates in matrix, $\times \frac{2}{3}$, p. 27. *ASG*, left antero-superognathal, in inner view; *AVL*, left antero-ventrolateral, outer view. (Posterior half is lacking.) *L*, lower arm of lateral, inner view; *Mnd*, impression of mandible, lacking anterior extremity; *PSG*, left postero-superognathal, inner view; *SO*, left suborbital, inner view. E 2374.

Fig. 2. Postero-superognathal, shown in figure 1, natural size.

Fig. 3. Antero-superognathal, shown in figure 1, natural size. It shows the functional region well and the articulating process.


AGS
SGP
SO
Mnd
L
AVL




3

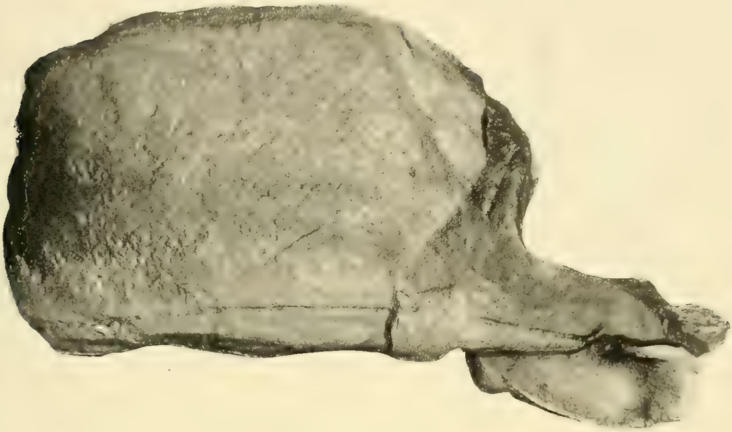
PLATE 6

Dinichthys terrelli Newberry

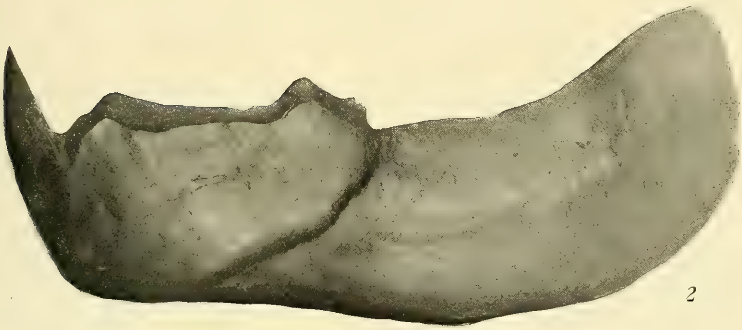
Cleveland shale (Upper Devonic); Linndale, near Cleveland, Ohio

Fig. 1. Right suborbital, outer view, × 1/5. The specimen is an impression in shale and the figure is of a cast made from it. E 2380, p. 32.

Figs. 2, 3. Left mandible, in outer (2), and inner (3), views. × 1/5. E 2379, p. 32.



1



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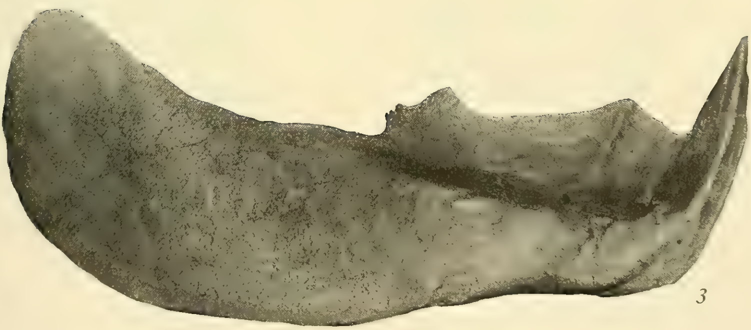


3

PLATE 7

Dinichthys magnificus, n. sp.

Plates belonging to type specimen, E 2381. Near base of Rhinestreet shale (Portage); Eighteen Mile Creek, near Hamburg, N. Y.

Fig 1. Left mandible, lacking blade, or inserted portion, in outer view. Somewhat less than $\times \frac{1}{2}$, p. 41.

Fig. 2. Right lateral, or "clavicular," in outer view, $\times \frac{1}{3}$. Figure is of a *cast*, of the specimen, which is an impression, p. 42.

Fig. 3. Right postero-ventrolateral, in outer view. $\times \frac{1}{4}$. Figure is of a *cast* of the specimen, which is an impression, p. 43.

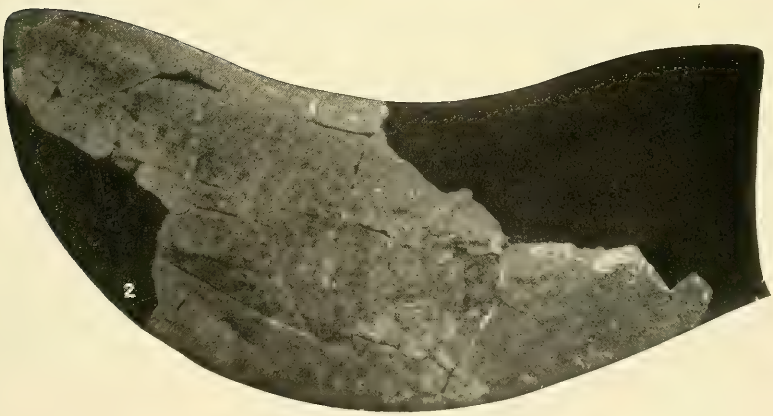
PLATE 8

Figs. 1, 1a. *Dinichthys magnificus*, n. sp. Anterior extremity of a left mandible, $\times \frac{3}{4}$. 1, outer view; 1a, inner view. E 1936, p. 43.

Fig. 2. *Dinichthys magnificus*, n. sp. Posterior, or inserted portion of a right mandible, $\times \frac{1}{2}$. The black portion of the figure is represented by the impression, the rest by actual bone. E 1960, p. 44.

1

1a



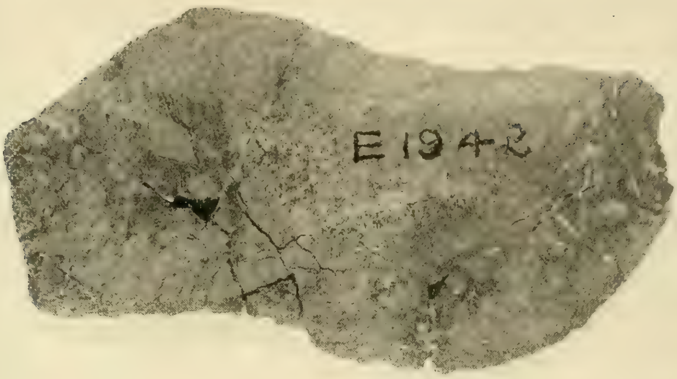
2

PLATE 9

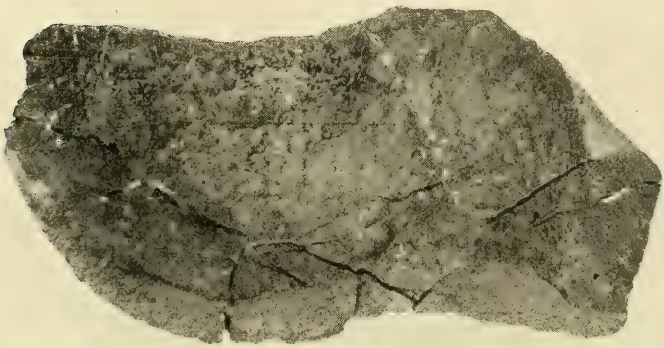
Dinichthys magnificus, n. sp.

Figs. 1, 2. Small left postero-superognathal; natural size. 1, outer view; 2, inner view. E 1942, p. 45.

Fig. 3. Imperfect large left postero-superognathal, outer view. Natural size E 1937, p. 44.



1



2

3

PLATE 10

Dinichthys newberryi Clarke

Figs. 1, 1a. Left antero-superognathal of a young individual, in inner (1), and outer (1a), views; natural size. E 1940, p. 49.

Fig. 2. Functional half of a left mandible, in matrix; outer view. $\times \frac{5}{6}$. E 2382, p. 48.

1

1a

2

PLATE 11

Dinichthys newberryi Clarke

Figs. 1, 1a. Left antero-superognathal, in outer (1), and inner (1a), views; natural size. E 1939, p. 48.

Figs. 2, 2a. Juvenile left antero-superognathal, in outer (2), and inner (2a), views; slightly larger than natural size. E 1955, p. 49.

1

2

1a

2a

PLATE 12

Dinichthys pustulosus Eastman

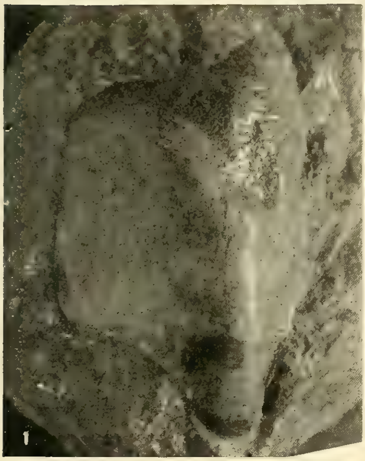
Hamilton limestone (Mid Devonic); Milwaukee, Wis. Originals in private collection of Mr. E. E. Teller, Buffalo, N. Y.

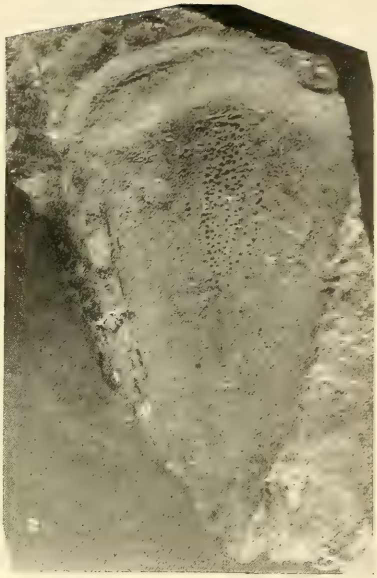
Fig. 1. Left antero-superognathal, in outer view. $\times \frac{2}{3}$. Cast of specimen E 2384, p. 51.

Fig. 2. Cast of antero-ventromedian, in outer view, showing ornamentation of fine tubercles, and extent of ornamented area. $\times \frac{3}{4}$. E 2385, p. 51.

Fig. 3. Right antero-dorsolateral, in outer view; margins restored. P. 51.

PLATE 12





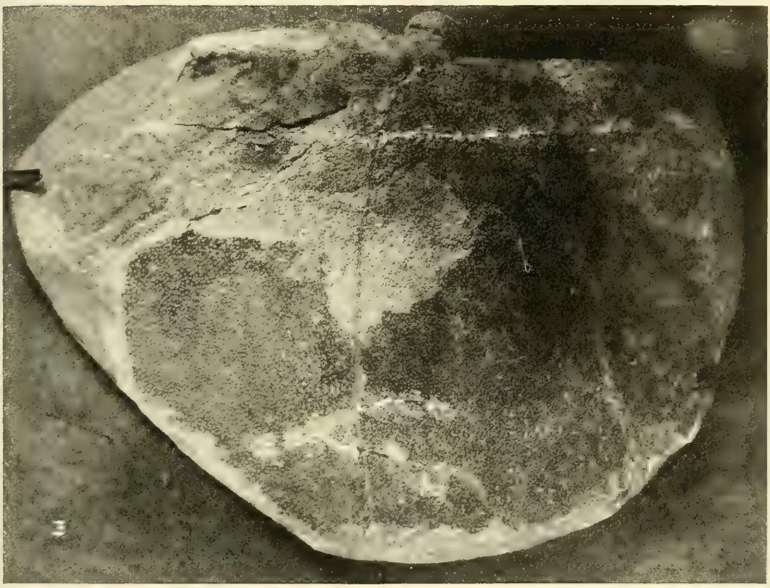


PLATE 13

Fig. 1. *Dinichthys pustulosus* Eastman. Rostral element in matrix; outer view. It shows the ornamentation well. Original in private collection of E. E. Teller, Buffalo, N. Y.

Fig. 2. Ditto. Beak of a right mandible, in inner view, showing row of symphyseal denticles (*s*). Natural size. E 1896. p. 51.

Fig. 3. *Dinichthys* sp. "Tooth" of a left antero-superognathal. $\times \frac{3}{4}$. (By inadvertance printed upside down.) E 1958, p. 62.

Fig. 4. *Dinichthys pustulosus* Eastman. Left marginal of a small cranium, showing sensory canal. $\times \frac{2}{3}$. E 1973, p. 52.

Fig. 5. *Dinichthys* sp. Half of a postero-dorsolateral, in outer view. $\times \frac{1}{2}$. E 1998, p. 63.

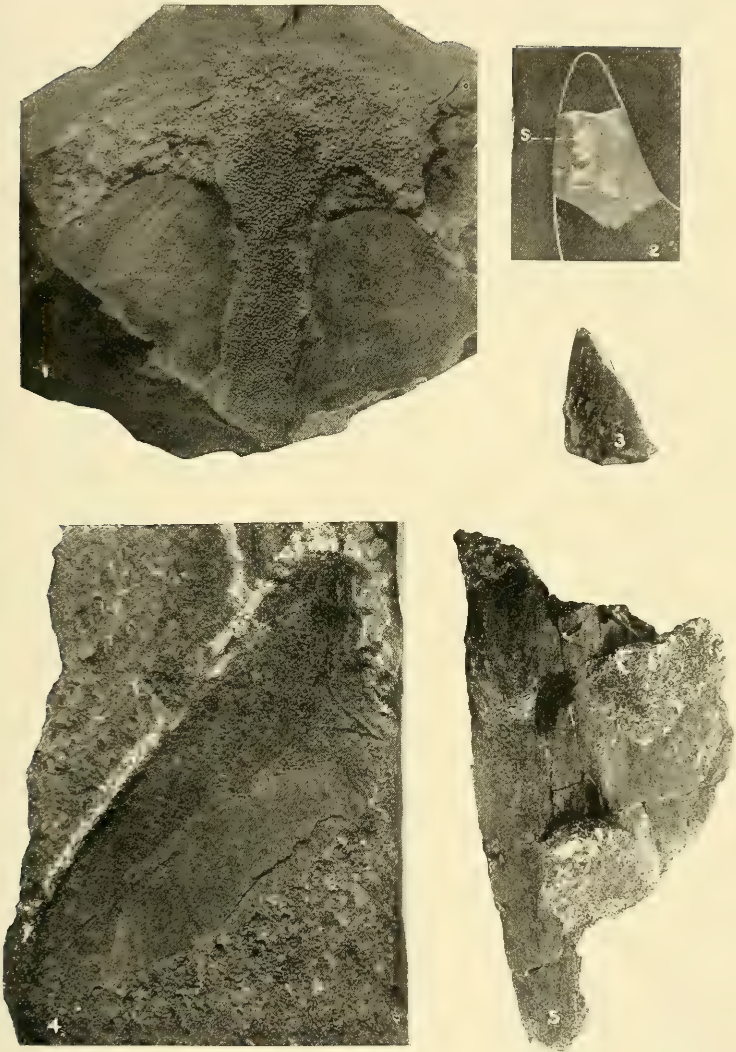

S
2
3
5

PLATE 14

Fig. 1. *Dinichthys* sp. Incomplete postero-ventrolateral, in matrix. Natural size. E 2511, p. 65.

Fig. 2. *Dinichthys* sp. Functional half of a right mandible, in outer view; much worn by use. Natural size. E 2510, p. 61.

1

2

PLATE 15

Fig. 1. *Stenognathus gouldi?* (Newberry). Anterior half of right mandible; outer view. Natural size, E 2392, p. 71.

Fig. 2. *Stenognathus ringuebergi* Newberry. Type. Dorsomedian. $\times \frac{3}{4}$. P. 69. Original in private collection of Mr. E. N. S. Ringueberg, Lockport, N. Y.

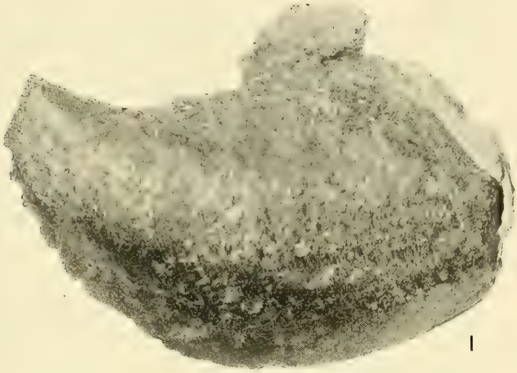
1

2

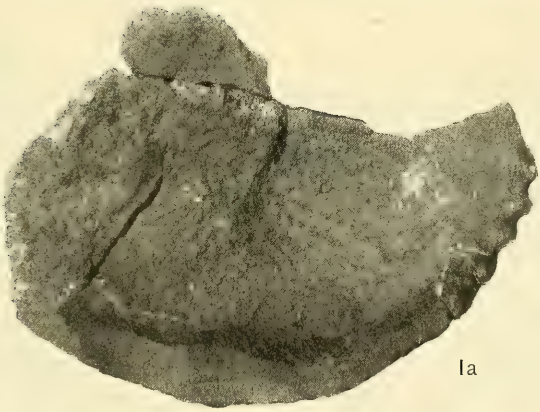
PLATE 16

Figs. 1, 1a. *Dinichthys* sp. Right postero-superognathal, in outer (1), and inner (1a), views. Natural size. E 1943, p. 62.

Fig. 2. *Dinichthys* sp. Right postero-superognathal, in matrix; inner view; natural size. E 2388, p. 62.



1



1a

2

PLATE 17

Fig. 1. *Dinichthys magnificus?* Rostral element in matrix; outer view. × ½. E 1981, p. 60.

Fig. 2. *Dinichthys* sp. Fragmentary plate ornamented with tubercles. × ¾. E 1996, p. 63.

Fig. 3. *Dinichthys* sp. Fragmentary plate ornamented with small tubercles; natural size. E 1997, p. 64.

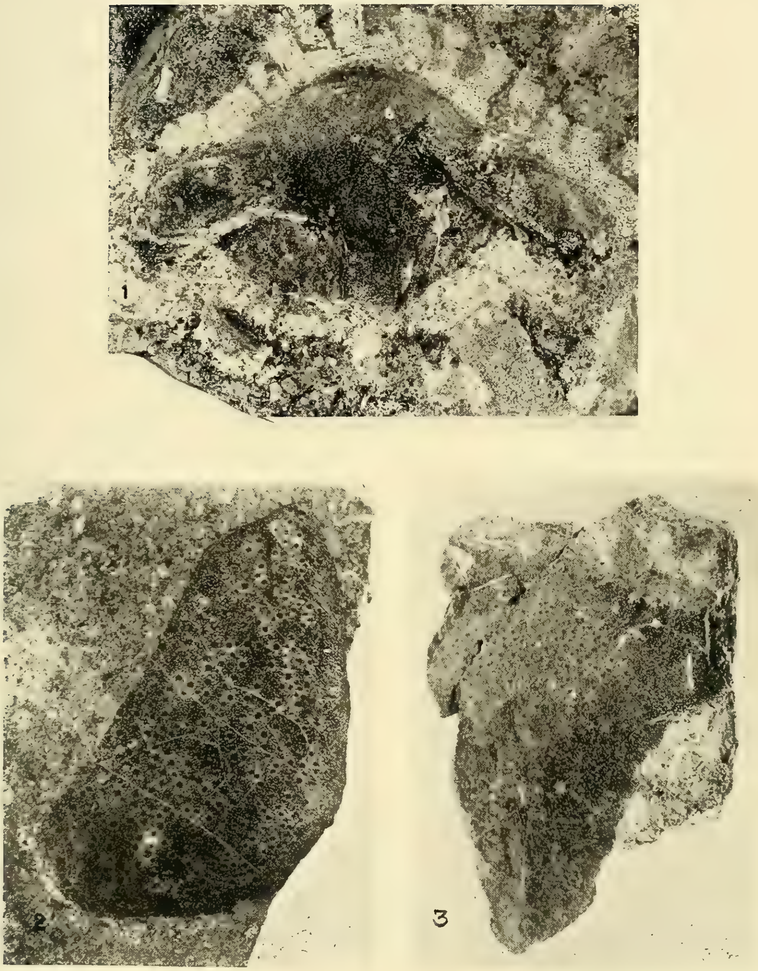

1
2
3

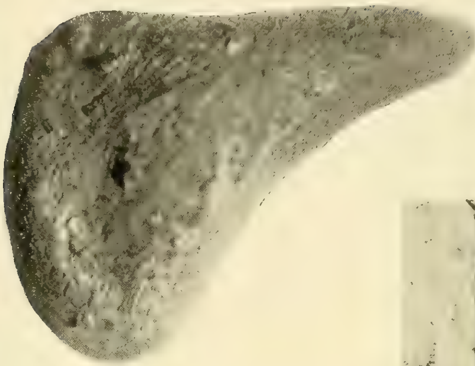
PLATE 18

Fig. 1. *Dinichthys* sp. A very small left antero-superognathal, $\times$ 5. This is the smallest antero-superognathal of *Dinichthys* ever found. E 1951, p. 61.

Fig. 2. *Dinichthys* sp. A juvenile right antero-ventrolateral; natural size. E 2389, p. 63.

Fig. 3. *Dinichthys* sp. Spiniferous plate, imperfect at one extremity, in matrix. $\times \frac{2}{3}$. E 2011, p. 64.

1



2

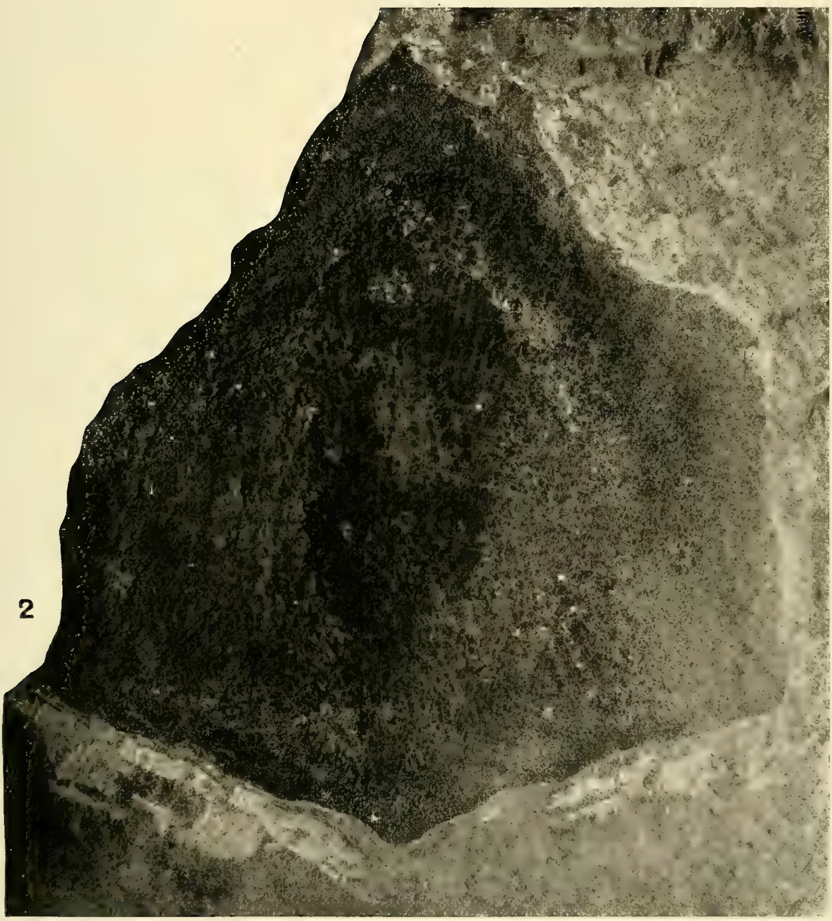
3

PLATE 19

Fig. 1. *Titanichthys* sp. Anterior third of a small right mandible, in inner, or oral, view. The anterior extremity is restored, and posteriorly the outer face is embedded in matrix. × ½. E 2391, p. 65.

Fig. 2. *Dinichthys* sp. Median occipital, ornamented with small tubercles arranged in linear series radiating from a center; in matrix. Natural size. E 2008, p. 60

1



2

PLATE 20

Figs. 1, 1a, 1b. *Perissognathus aduncus*, n. g., n. sp. Type. Right mandible in matrix; outer view. Natural size. E 2397, p. 81.

1a. Symphyseal region of type, showing the row of upturned symphyseal denticles. Natural size.

1b. Another view of same.

Fig. 2. Small element, probably a lateral of an indeterminate Arthrodire. Natural size. E 1988, p. 97.

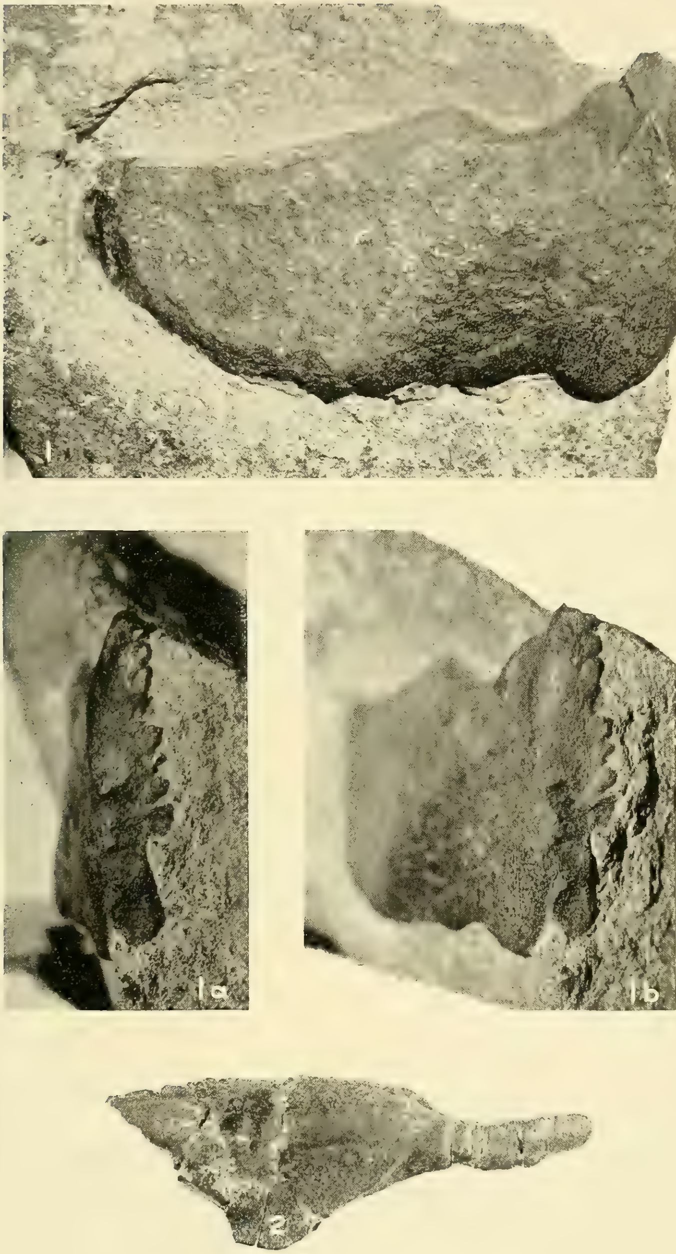

1
1a
1b
2

PLATE 21

Figs. 1, 1a, 1b. *Machærognathus woodwardi*, n. g., n. sp. Type. Right mandible, lacking posterior extremity, $\times \frac{2}{3}$. E 1935, p. 83.

1, outer view; 1a, inner view; 1b, as it appears resting on the outer face, to show sigmoidal curvature, antero-posteriorly.

Fig. 2. *Stenognathus insignis*, n. sp. Type. Right mandible, in outer view. $\times \frac{4}{5}$ E 1932, p. 73.

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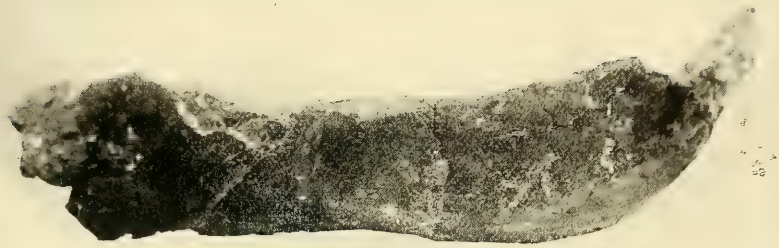

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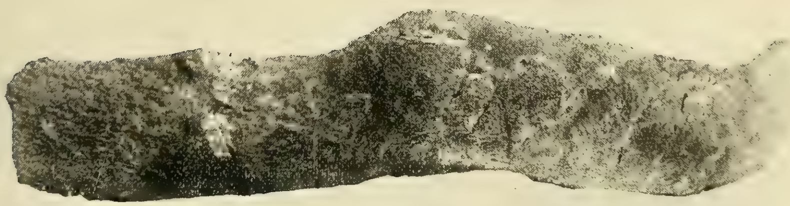

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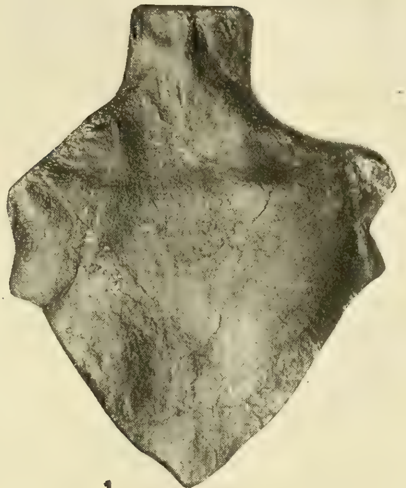
PLATE 22

Fig. 1. *Dinichthys magnificus*, n. sp. Cast of postero-ventrolateral belonging to type specimen; inner view. $\times \frac{1}{4}$. E 2381, p. 42.

Fig. 2. *Copanognathus crassus*, n. g., n. sp. Microsection of type mandible, p. 84.

Fig. 3, 4. *Copanognathus crassus*, n. g., n. sp. Sections of type mandible; natural size. 3, section near posterior extremity; 4, section at about first third, p. 84

3



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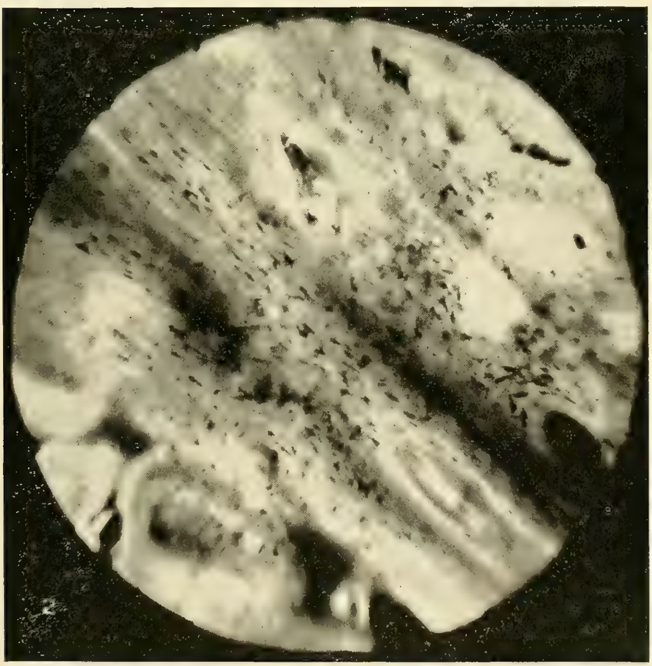


PLATE 23

Fig. 1. *Dinomylostoma buffaloensis*, n. sp. Right mandible, in matrix; outer view. $\times \frac{3}{4}$. E 1964, p. 88.

Fig. 2. *Dinomylostoma* sp. Left mandible of a juvenile individual. $\times 1\frac{1}{3}$. E 2042, p. 90.


1


2

PLATE 24

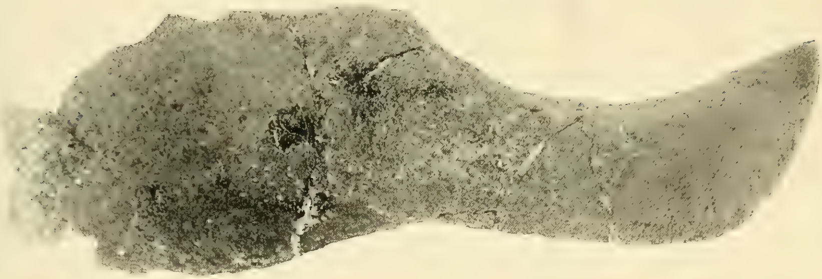
Fig. 1. *Dinomylostoma buffaloensis*, n. sp. Cotype. Right mandible, lacking posterior half of inserted portion, in outer view. Natural size. E 1961, p. 86.

Fig. 2. *Dinomylostoma buffaloensis*, n. sp. Cotype. Left mandible, lacking only a very little of the posterior extremity; in inner view. A part of outer face is embedded in matrix. $\times$ about $\frac{2}{3}$. E 1965, p. 86.

Fig. 3. *Dictyopyge macrura* (W. C. Redfield). Fragment of head plate enlarged 10 times, to show style of ornamentation. E 2126, p. 193.

Fig. 4. *Dinomylostoma buffaloensis*, n. sp. Functional half of a left mandible; inner view. $\times$ $\frac{2}{3}$. E 1966, p. 88.

Fig. 5. *Dinomylostoma buffaloensis?* Functional half of a left mandible; outer view. $\times$ $\frac{2}{3}$. E 1968, p. 89.



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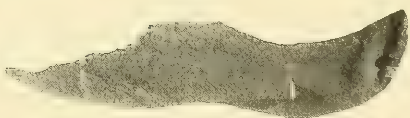

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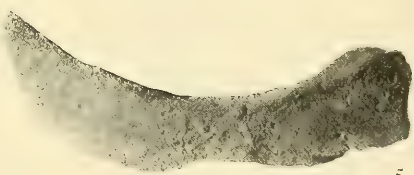

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PLATE 25

Aspidichthys notabilis Whiteaves

Right antero-ventrolateral, incomplete anteriorly; outer view. The posterior extremity is restored from a squeeze of impression in the matrix. $\times \frac{3}{4}$. E 1970, p. 93.

PLATE 26

Aspidichthys notabilis Whiteaves

Fig. 1. Front half of antero-ventromedian. Photographed from a cast, original being an impression. Natural size. E 2399, p. 93.

Fig. 2. Fragmentary plate, perhaps part of a ventral. $\times \frac{2}{3}$. E 1971, p. 93.

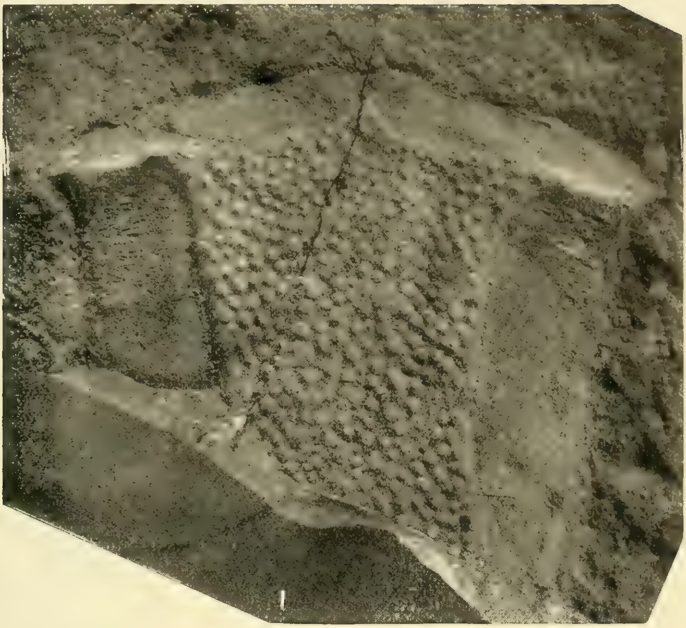


PLATE 27

Fig. 1. *Dinichthys* sp. Juvenile right antero-superognathal, in outer view; natural size. E 1954, p. 62.

Fig. 2. *Dinichthys newberryi?* juvenile. Left antero-superognathal, in outer view; natural size. E 1956, p. 49.

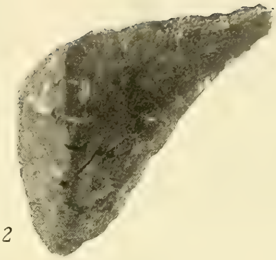
Fig. 3. *Dinichthys insolitus*, n. sp. Type. Right antero-superognathal. Natural size. E 2387, p. 53.

Figs. 4, 4a. *Perissognathus aduncus*, n. g., n. sp. Beak of a left mandible of about same size as the type (see Pl. 20), showing the symphyseal denticles well. Natural size. 4, outer view; 4a, inner view. E 2165, p. 83.

Figs. 5, 6. *Dinomylostoma?* Two upper dental elements, in oral view. Natural size. E 1859 and E 2398, p. 90.

Fig. 7. Small left antero-superognathal of an undetermined Arthrodire. $\times \frac{3}{4}$ E 1946, p. 96.


1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4a


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6


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PLATE 28

Fig. 1. *Dinichthys?* Plate in matrix, outer view; natural size. E 2035, p. 65.

Fig. 2. Dinichthyid, sp. indet. Very small juvenile lateral, or "clavicular," in matrix; outer view. $\times$ 2. E 2043, p. 97.

Fig. 3. *Dinichthys newberryi?* Postero-ventromedian. $\times \frac{3}{5}$, E 1986, p. 50.

Fig. 4. *Acanthaspis* sp. Detached lateral spine. $\times$ 2. E 2013, p. 100.

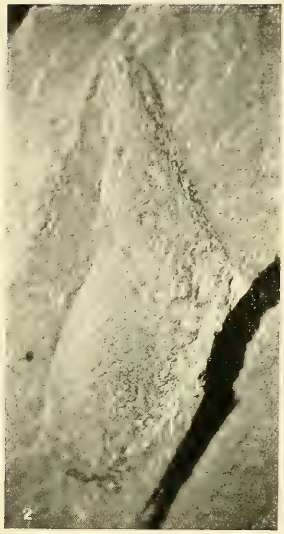

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PLATE 29

Fig. 1. *Selenosteus?* sp. Ventral plates, natural size. E 2022, p 81.

Fig. 2. *Eczematolepis fragilis* (Newberry). Plate in matrix. × $\frac{3}{4}$. E 1856, p. 102.

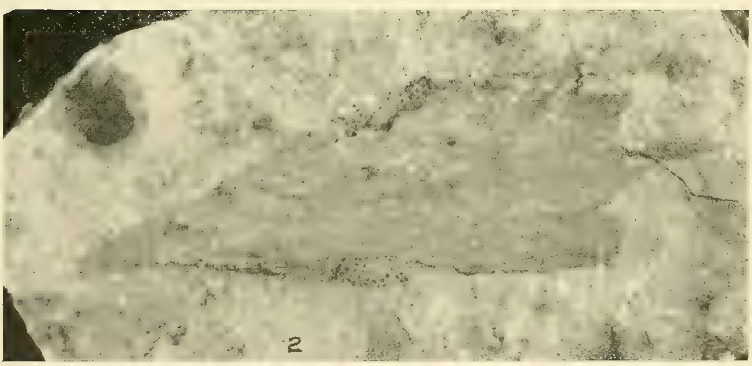
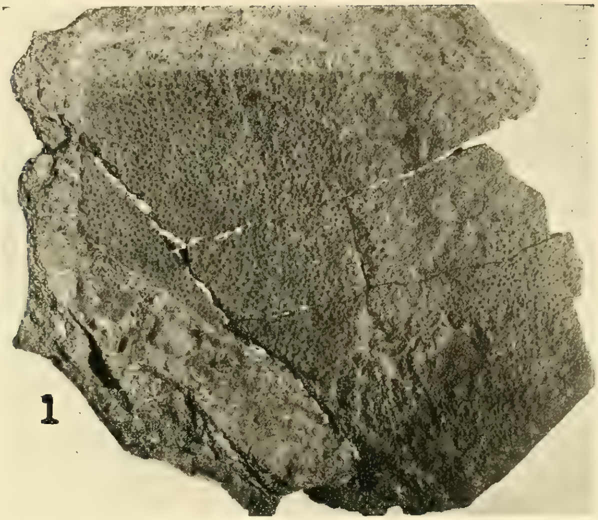


PLATE 30

Fig. 1. *Eczematolepis fragilis* (Newberry). Incomplete plate in matrix; outer face. It shows the ornamentation of fine tubercles. Natural size. E 2014, p. 102.

Fig. 2. *Acanthaspis* sp. Antero-ventrolateral, in matrix; inner, or visceral, face. Natural size. E 2024, p. 101.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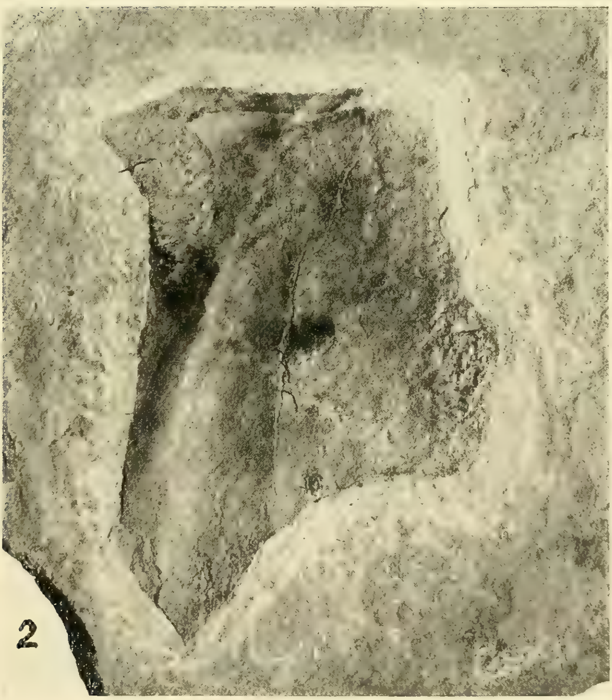
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PLATE 31

Holonema abbreviatum (Eastman).

Plate showing well the characteristic ornamentation; in matrix. Natural size. E 2025, p. 102.

PLATE 32

Fig. 1. *Holonema rugosum* (Claypole). Cast of a complete plate. It shows tooth marks made by a Dinichthyid. Natural size. E 2513, p. 104.

Original in private collection of Mr. E. E. Teller, Buffalo, N. Y.

Fig. 2. *Phyllolepis elegans*, n. sp. Type. Plate in matrix Natural size. E. 2438, p. 21.

1

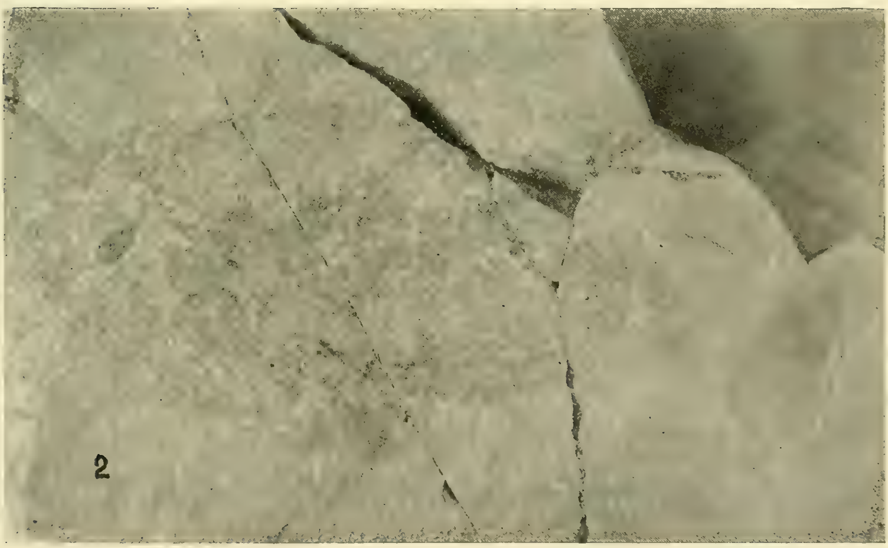

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PLATE 33

Fig. 1. *Oëstophorus lilleyi* (Newberry). Fragmentary plate showing characteristic arrow-head-like ornamentation. × 2½. Conodont bed. E 2012, p. 105.

Fig. 2. *Holonema* sp. Cast of a fragmentary plate, remarkable for its thickness (over 1 cm.). Natural size. E 2512, p. 104.

Original in private collection of Mr. Edgar E. Teller, Buffalo, N. Y.

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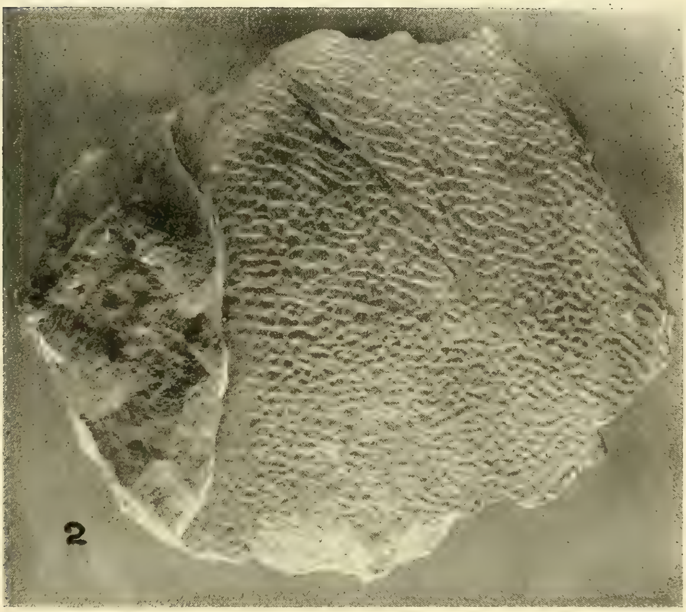

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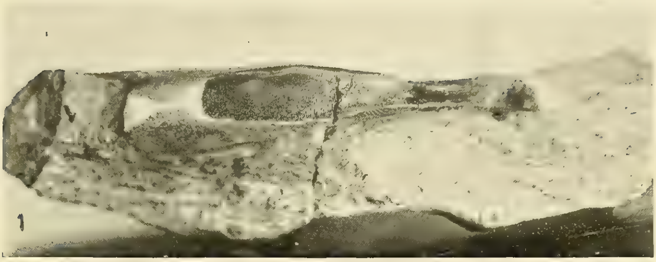
PLATE 34

Figs. 1, 3. *Ptyctodus calceolus* Newb. and Worthen. Right lower dental plate; natural size. 1, oral view, showing entire tritor; 3, inner view. E 1884, p. 108.

Fig. 2. Microsection of *Ptyctodus calceolus*, cut parallel to the side wall of the tritor.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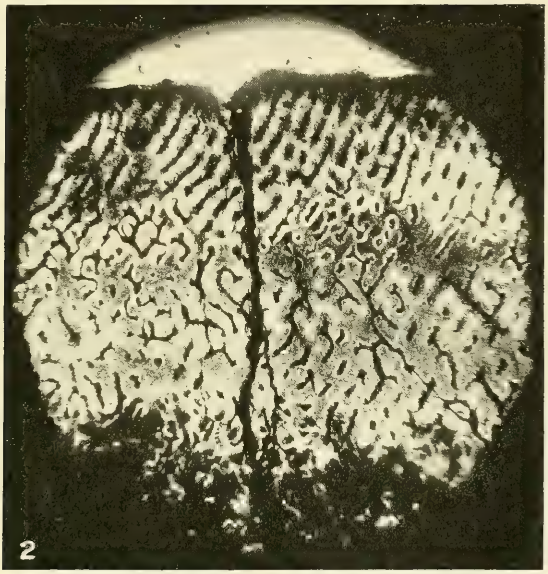
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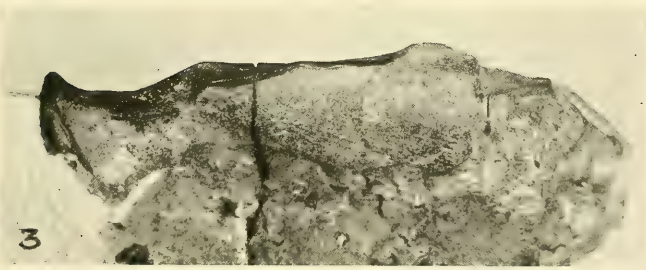
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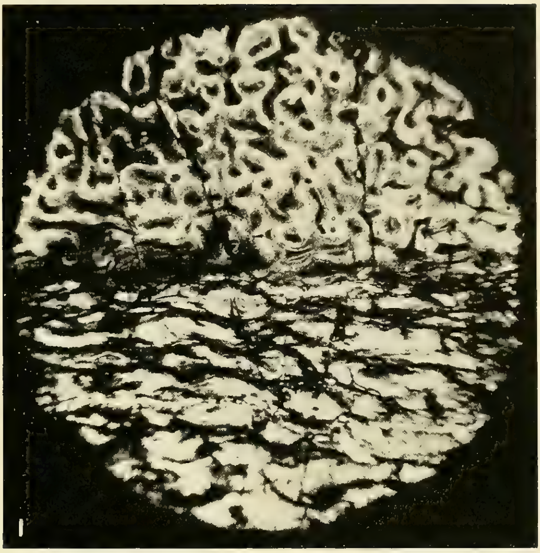
PLATE 35

Microsections of *Ptyctodus howlandi*, n. sp., p. 112.

Fig. 1. Section parallel to side wall of tritor.

Fig. 2. Portion of the same more highly magnified to show the radiating tubules.



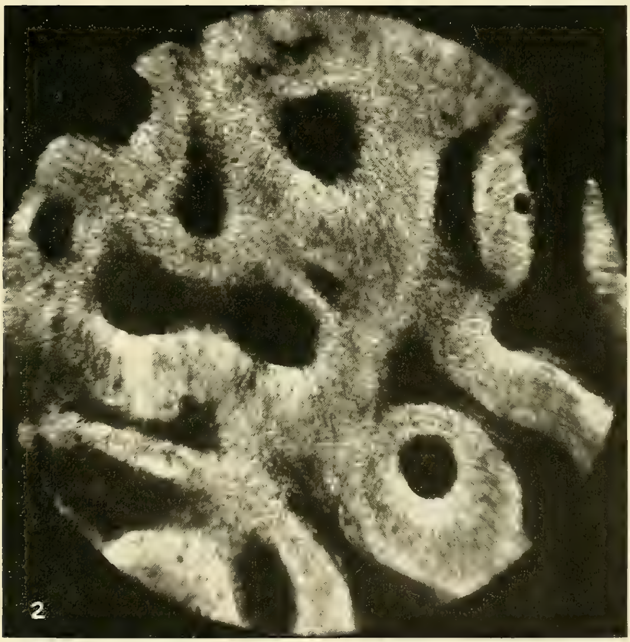


PLATE 36

All figures natural size

Figs. 1, 2, 10. *Ptyctodus calceolus* Newb. and Worthen.

1, 2, E 1913, p. 109.

10, E 2431, p. 109.

Figs. 3–9; 11, 12. *Ptyctodus compressus* Eastman.

3, E 1914, p. 110.

4, E 2410, p. 111.

5, E 1916, p. 110.

6, E 1917, p. 110.

7, E 2432, p. 115.

8, E 1914, p. 110.

9, E 1912, p. 110.

11, E 2433, p, 111.

12, E 1914, p. 110.

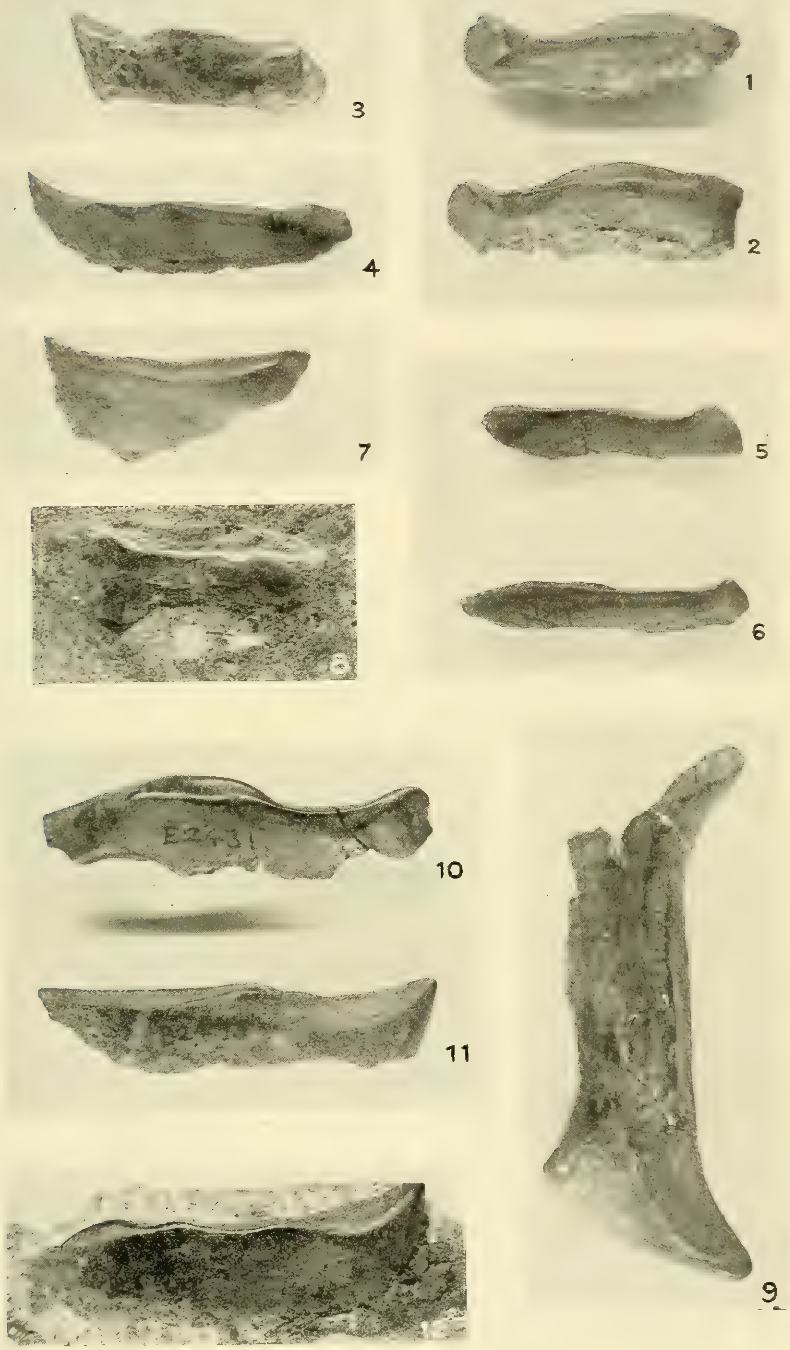

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PLATE 37

All figures natural size

Figs. 1–8; 10–13. *Ptyctodus compressus* Eastman.

1, E 2406, p. 111.
2, E 1917, p. 110.
3, E 1914a, p. 110.
4, E 1914, p. 110.
5, E 1914a, p. 110.
6, E 1914, p. 110.

7, E 2433 (By inadvertence this is the same specimen as the one figured in Pl. 36, fig. 11.)

8, E 2432, p. 111.
10, E 2408, p. 111.
11, E 2404, p. 111.
12, E 1911, p. 110.
13, E 2408, p. 111.

Fig. 9, *Ptyctodus calceolus* Newb. and Worthen, E 1913, p. 109.

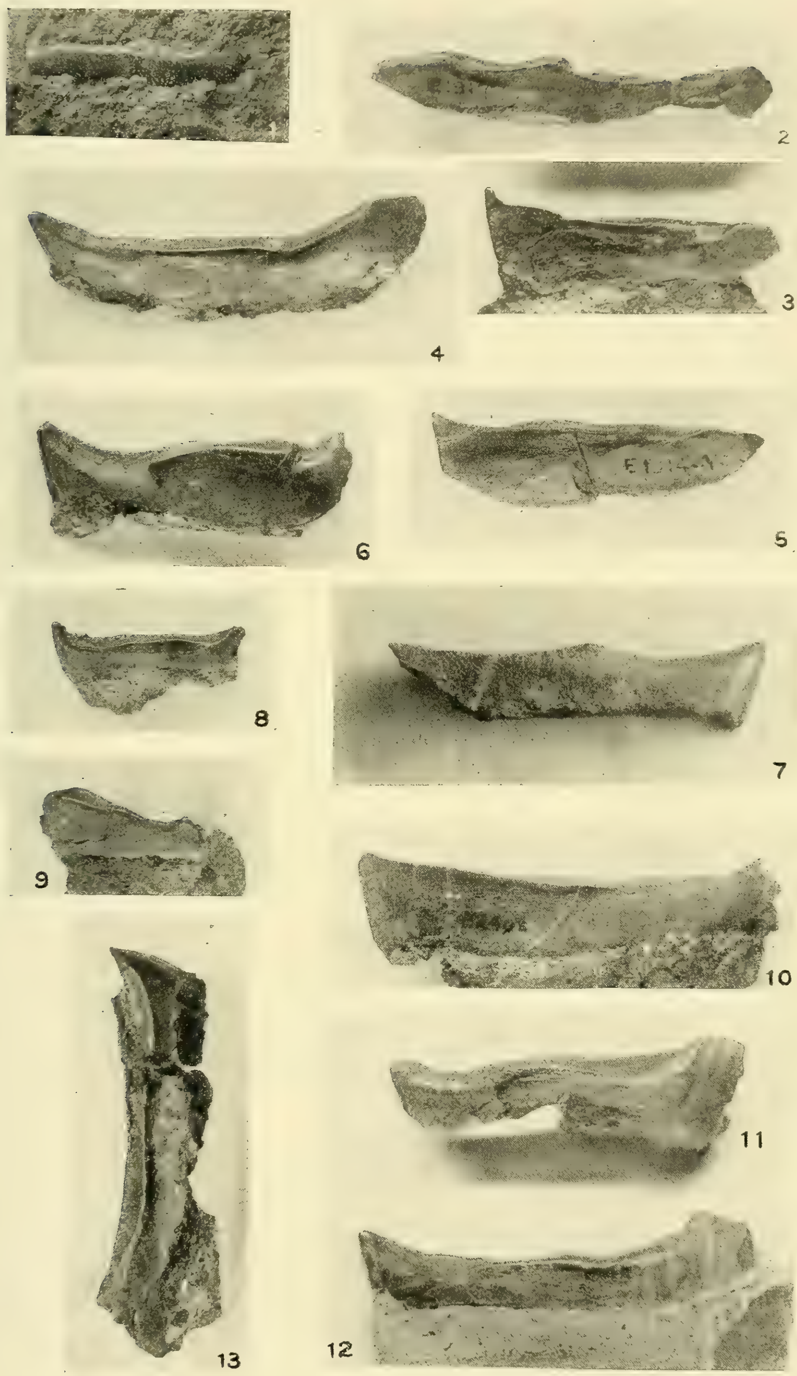
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PLATE 38

Ptyctodus howlandi, n. sp.

Figs. 1, 4, 5. Type. Left lower dental plate, × about $\frac{3}{4}$. E 1919, p. 112.
1, outer view; 4, inner view; 5, oral view (the anterior downward).

Fig. 2. Left lower dental plate, × $\frac{3}{4}$. E 2426, p. 115.

Fig. 3. Enlargement of surface view of tritoral area of type specimen.

Fig. 6. Right lower denta plate, natural size, showing tritoral area. E 2421, p. 115.

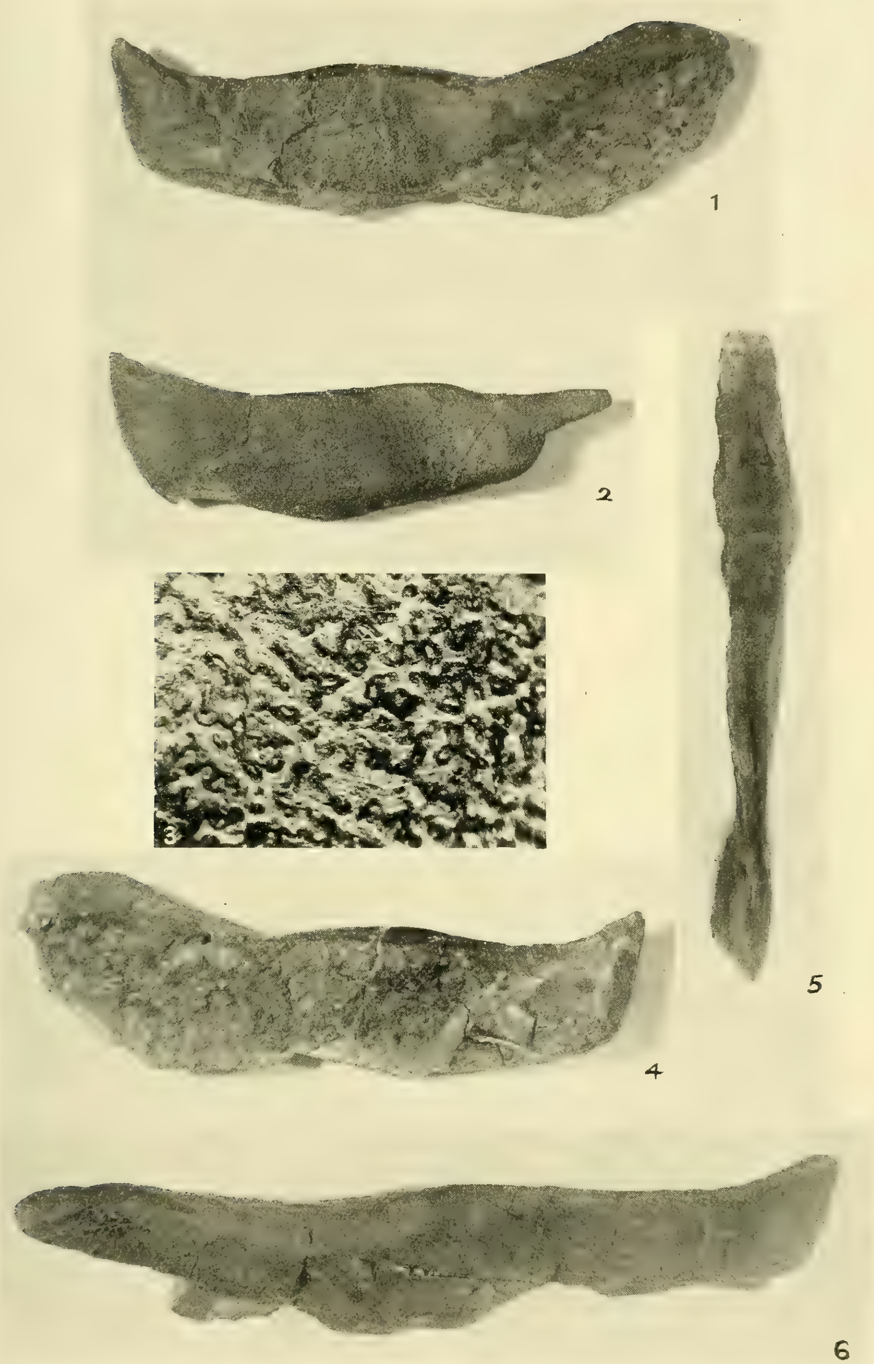
1
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PLATE 39

Rhynchodus ornatus, n. sp.

Figs. 1, 1a, 2. Cotypes. Two left lower dental plates, posteriorly incomplete, p. 117.

1, outer view, natural size. E 1950.

1a, the same enlarged about $1\frac{1}{2}$ times, to show ornamentation of longitudinal lines.

2, outer view, natural size. E 1950 a. It shows the entire cutting margin, which is imperfect in Cotype 1. Note same style ornamentation as in Cotype 1, near lower margin.

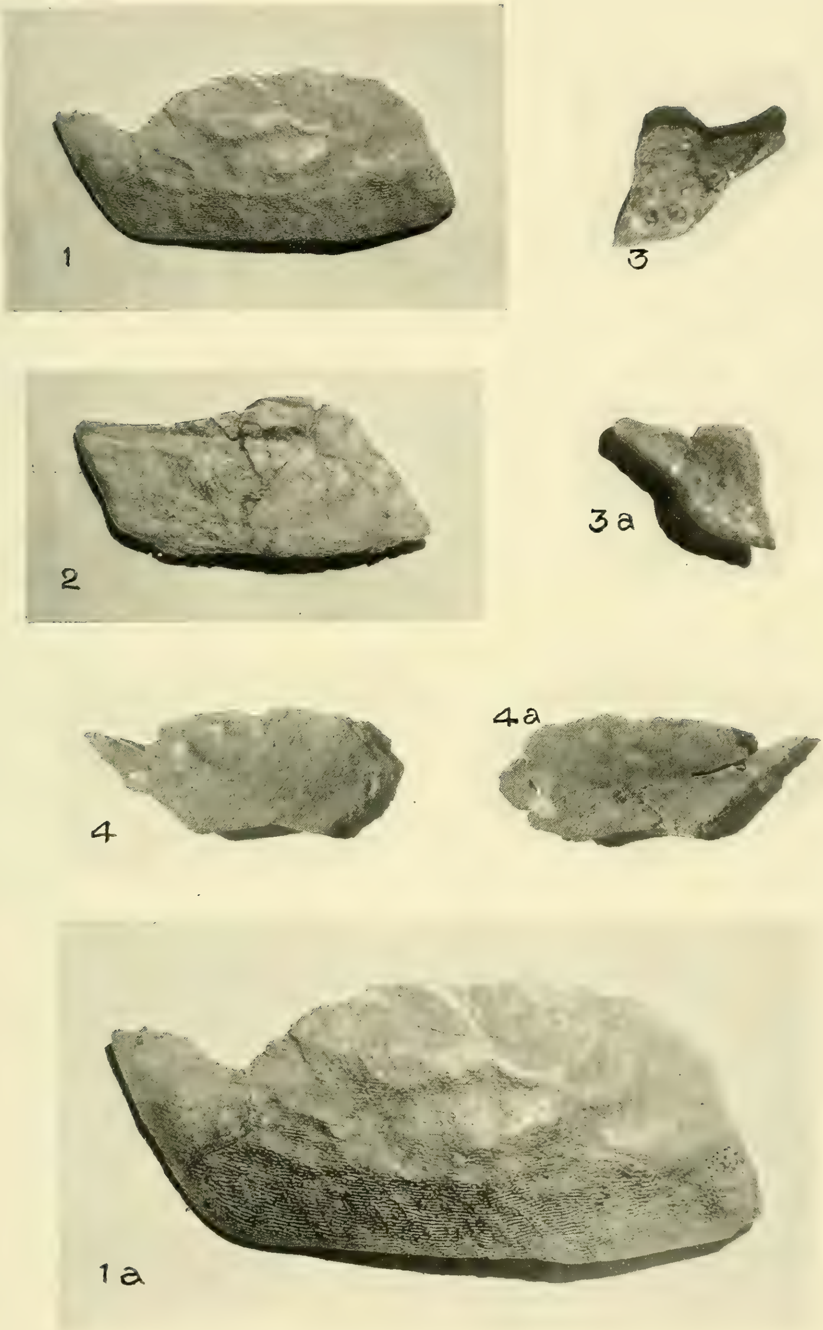
Figs. 3, 3a. Anterior portion of a dental plate, ornamented on both outer and inner faces with a few pronounced, smooth tubercles. Natural size. E 1947 a, p. 118.

3, outer view. (The beak is toward the right.) Note 3 or 4 large, low tubercles.

3a, inner view. Note the beveled cutting margin, and 2 or 3 low, smooth tubercles.

Figs. 4, 4a. Dental plate, showing a few low, smooth protuberances or tubercles. Natural size. E 1947, p. 118.

4, outer view; 4a, inner. (The anterior cusp is not a beak; it has a specious appearance due to a part of the cutting margin being broken away.)


1
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3a
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4a
1a

PLATE 40

Figs. 1, 2, 3. *Ptyctodus* sp. Three tritors in profile view, to show progressive wearing down with use.

1, E 2407; natural size.

2, E 1926 (2); $\times \frac{3}{4}$, p. 114.

3, E 1926; natural size, p. 114.

Fig. 4. *Palæomylus* sp. Small dental plate (juvenile?), in inner view; natural size. E 2448, p. 123.

Fig. 5. Anterior portion of dental plate, inner view; natural size. E 2449, p. 123.

Fig. 6. *Palæomylus lunaformis*, n. sp. Type. Dental plate, natural size. E 1928, p. 119.

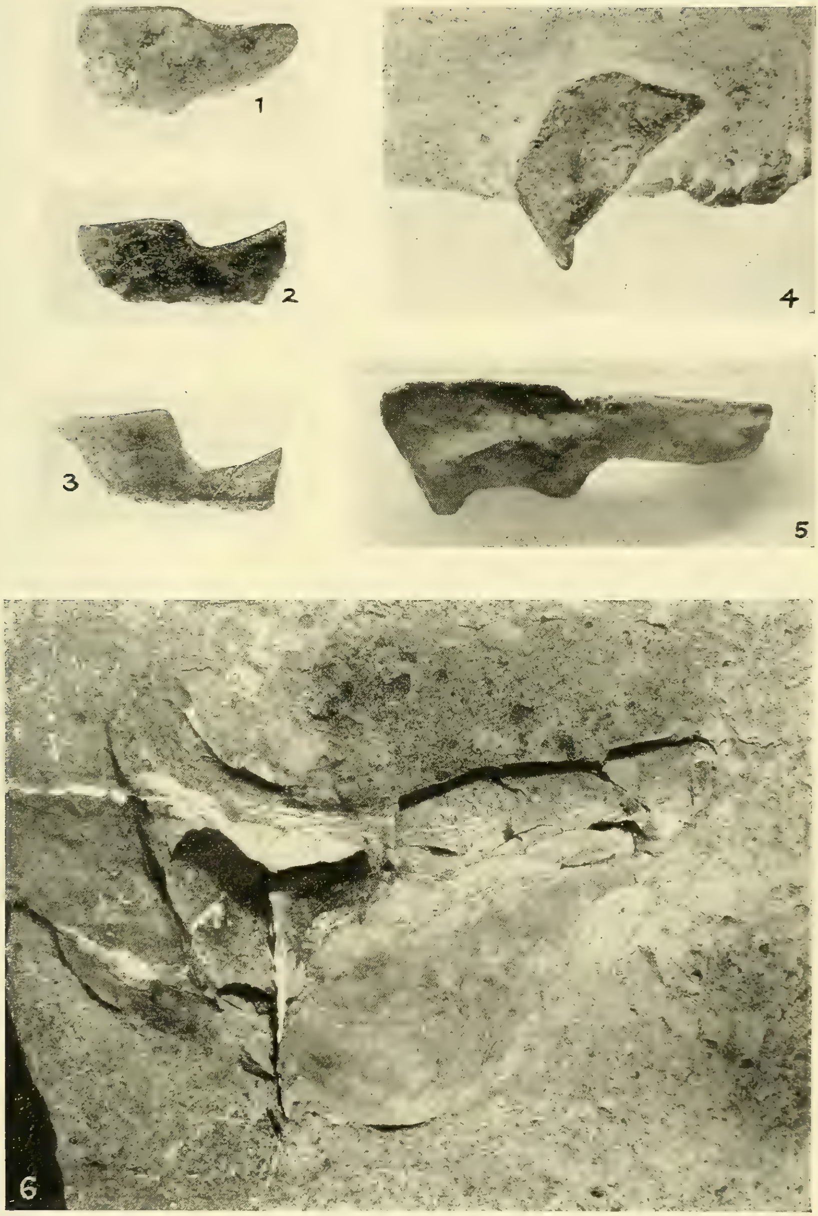
1
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PLATE 41

Figs. 1, 2. *Palæomylus* sp. A right lower dental plate (E 2446), and the beak of a left one (E 2453), p. 122.

1, profile view, × about $\frac{7}{8}$. 2, oral view, × $\frac{2}{3}$.

Figs. 3, 4, 5. *Palæomylus* sp. Three fragments of dental plates of same species as preceding, showing tritoral region. × $\frac{2}{3}$. E 1929 and E 1930, p. 122.


1


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PLATE 42

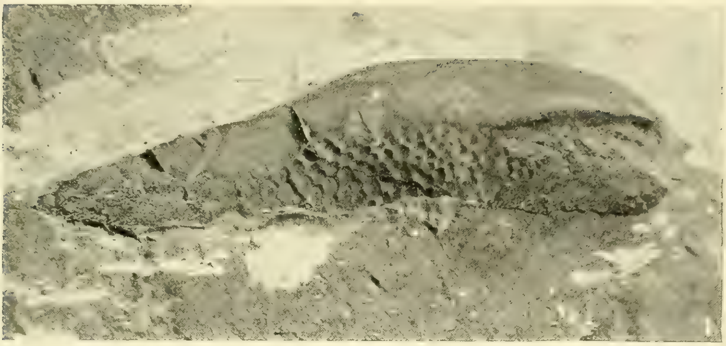
Deinodus bennetti, n. g., n. sp.

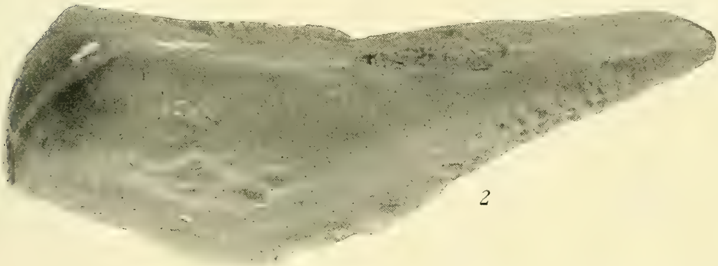
All figures natural size

Fig 1. An elongated, tapering plate, embedded with one face in matrix. Three sides are shown, the lateral ones ornamented with tubercles and the one between them smooth. The latter and one of the ornamented sides are shown in the figure. E 2451, p. 125.

Fig. 2. A plate resembling the preceding. The opposite side to the one shown in the figure is excavated with vascular surfaces as though for a pulp cavity. E 2461, p. 126.

Fig. 3. Type. Dental plate, slightly defective posteriorly, in outer view. It shows the beak, the bevelled functional margin, and the tubercles ornamenting the outer face. E 1856, and counterpart, E 2450, p. 123.





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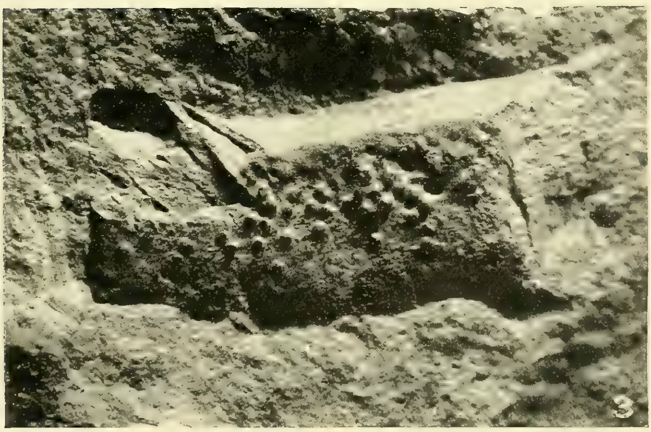


3

PLATE 43

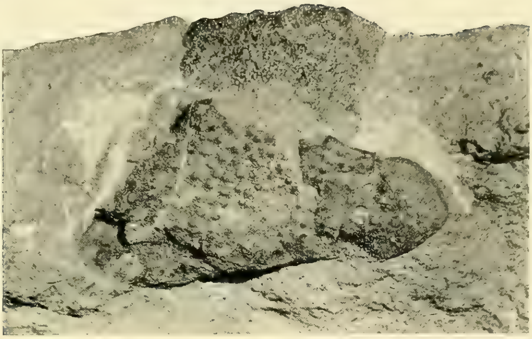
Deinodus bennetti, n. g., n. sp.

All figures natural size

Fig. 1. Fragmentary plate, showing characteristic ornamentation. E 2460, p. 126.

Fig. 2. Plate, partly restored. E 2493, p. 126.

Fig. 3. An elongated, tapering element similar to the one in Plate 42, figure 1, showing near one end the tuberculated ornamentation. E 2468, p. 126.



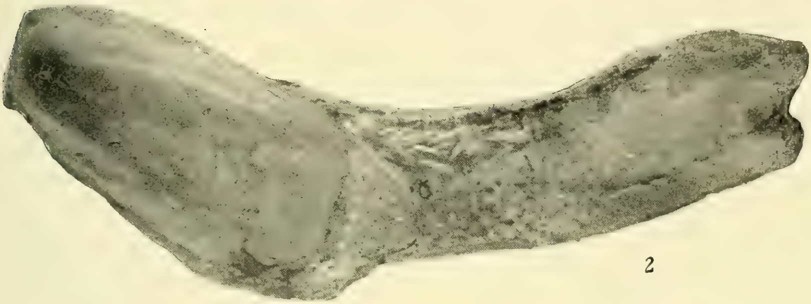


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PLATE 44

Figs. 1, 1a. *Cladodus urbs-ludovici* Eastman. Tooth in front (1), and lateral (1a), views. × 3. E 1900., p. 139.

Fig. 2. *Anodontacanthus pusillus*, n. sp. Type. Small spine, incomplete at both extremities. × 3. E 1915, p. 156.

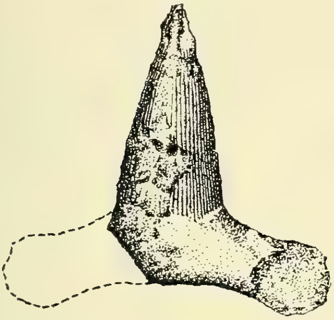
Figs 3, 3a, 3b. *Dittodus priscus* (Eastman). 4. E 1901, p. 144.

3. Tooth in front view, showing ornamentation.

3a. Outline of side view of another tooth, to show antero-posterior width of root and position of the "button."

3b. Tooth from above, to show entire root and the "button."

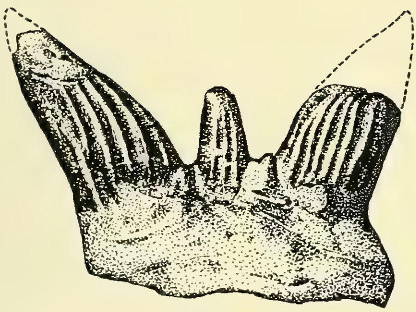
Fig. 4. *Orodus devonicus*, n. sp. Type. Tooth, × 3. E 1903, p. 153.



1

1a

2



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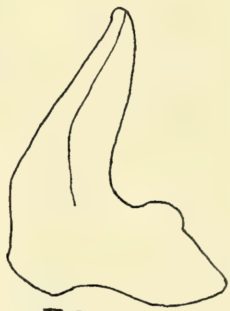
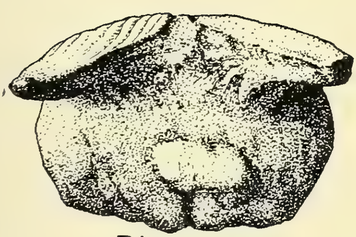


3a



3b

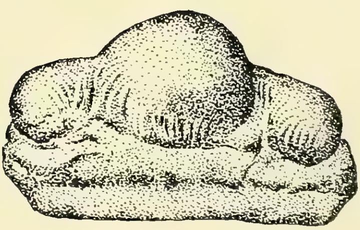


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PLATE 45

Cladoselache acanthopterygius Dean. Shark, lacking head, but displaying pectoral fins and entire length of body to caudal. × $\frac{1}{3}$. E 2474, p. 128.

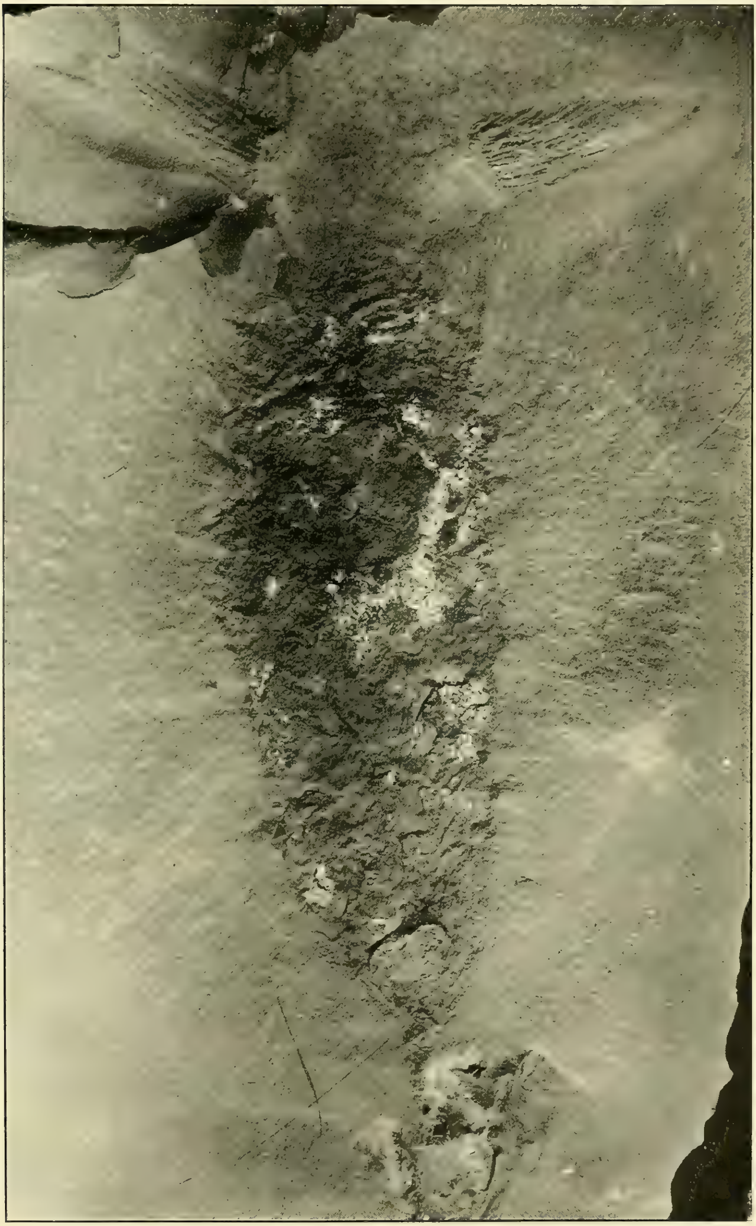

PLATE 46

Cladoselache brachypterygius Dean. Shark lacking caudal extremity. The pectorals are well shown. $\times \frac{1}{4}$. E 2475, p. 130.

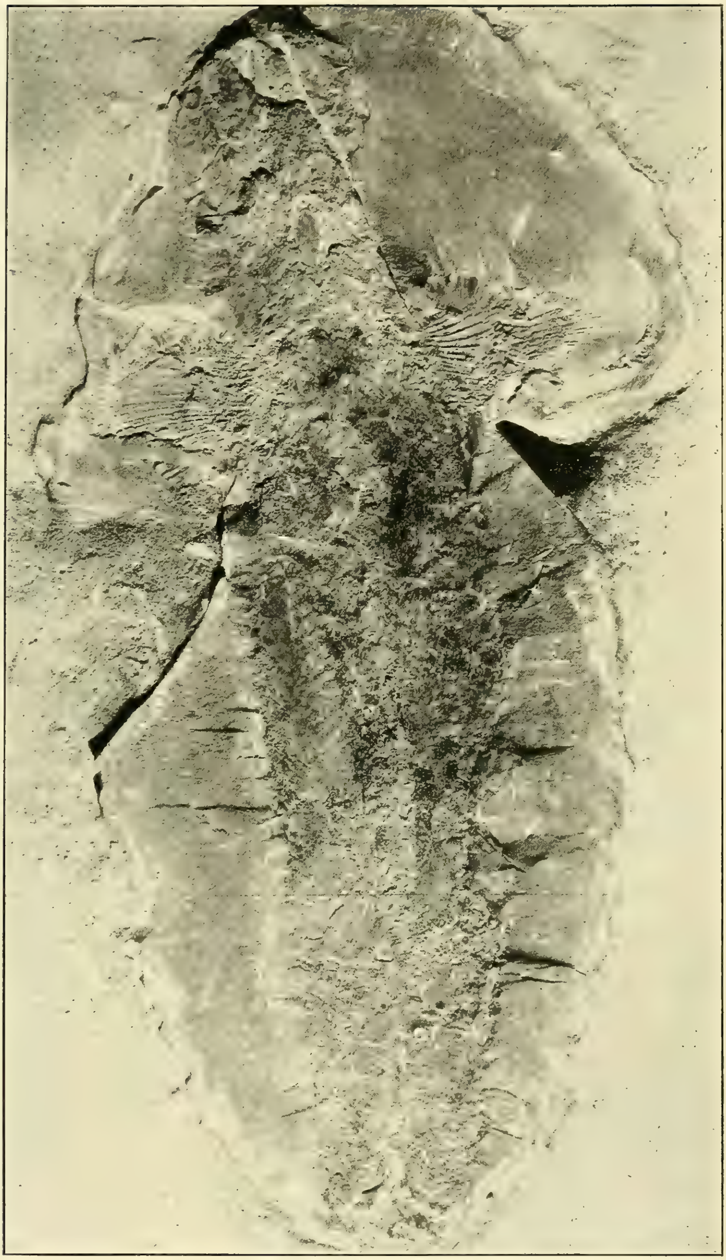

PLATE 47

Cladoselache desmopterygius Dean. Front half of a shark, showing well the head and one pectoral fin. $\times \frac{1}{3}$. E 2476, p. 130.

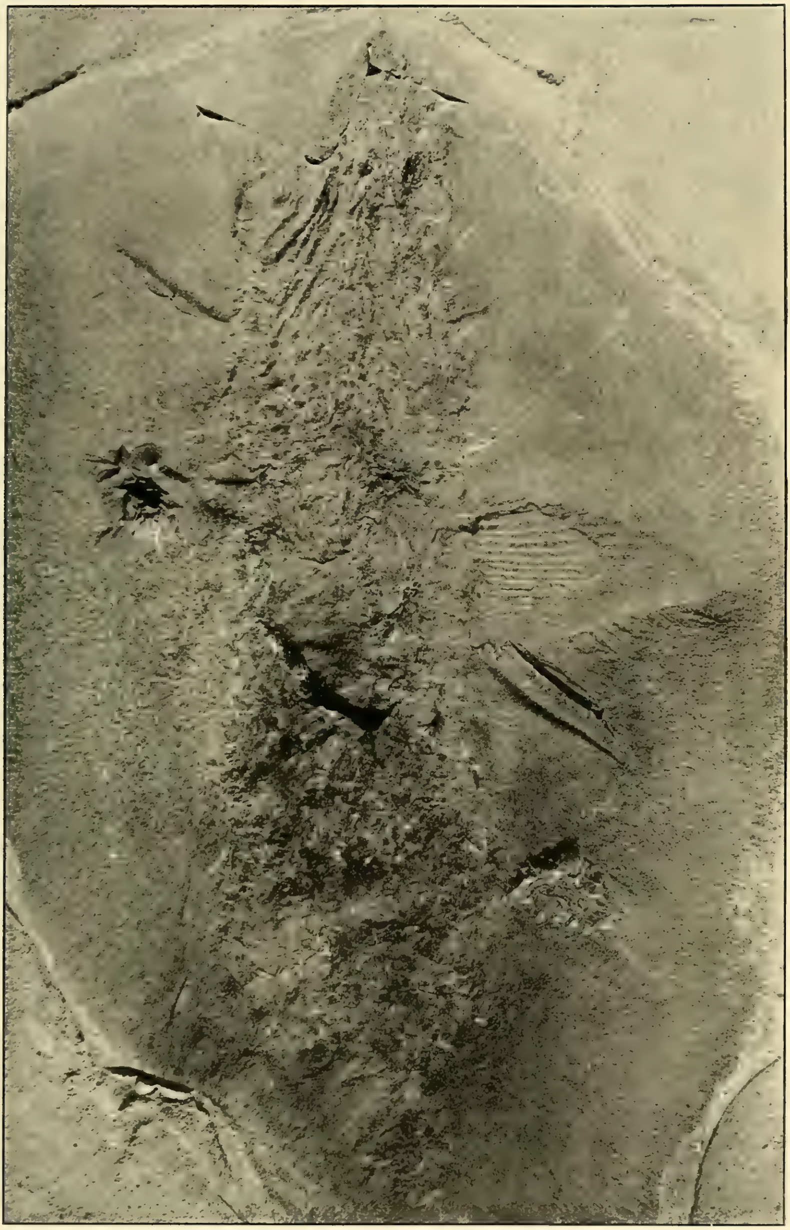

PLATE 48

Cladoselache fyleri (Newberry). Complete shark, 39 cm. in length, in ventra. view. It shows well the pectorals and the lateral caudal keels. × $\frac{1}{3}$. E 2480, p. 134.

The black streaks extending from the head diagonally toward the upper corners of the figure, and also three lesser ones in the lower half of the fish, are formations in the matrix and not part of the shark.

PLATE 49

Cladoselache kepleri (Newberry). Complete shark, 160 cm. in length, as far as preserved; in ventral view. $\times \frac{1}{10}$. It shows well the blunt head, the pectorals, one ventral, and one lobe of the caudal fin. E 2481, p. 135.

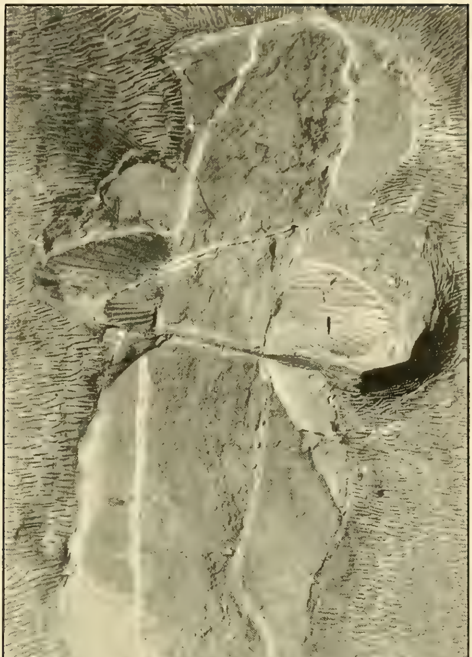

PLATE 50

Cladoselache kepleri (Newberry). Part of a large shark showing the ventral fins. × ½. E 2482, p. 137.

PLATE 51

Fig. 1. *Ctenacanthus nodocostatus*, n. sp. Type. Complete spine. Original is an impression in sandstone, and the figure is from a wax squeeze of it. Natural size. E 2083, p. 159.

Fig. 2. *Acanthodes concinnus* Whiteaves. Enlargement of shagreen, × about 15. Taken from specimen E 2485 (see text-fig. 50), p. 141.

Fig. 3. Acanthodin spine, in matrix. × 6. E 2486, p. 142.

Fig. 4. *Acanthodes concinnus* Whiteaves. Pectoral fin-spine of specimen of which shagreen is figured (this plate, fig. 2). E 2485. × $3\frac{1}{2}$, p. 141.

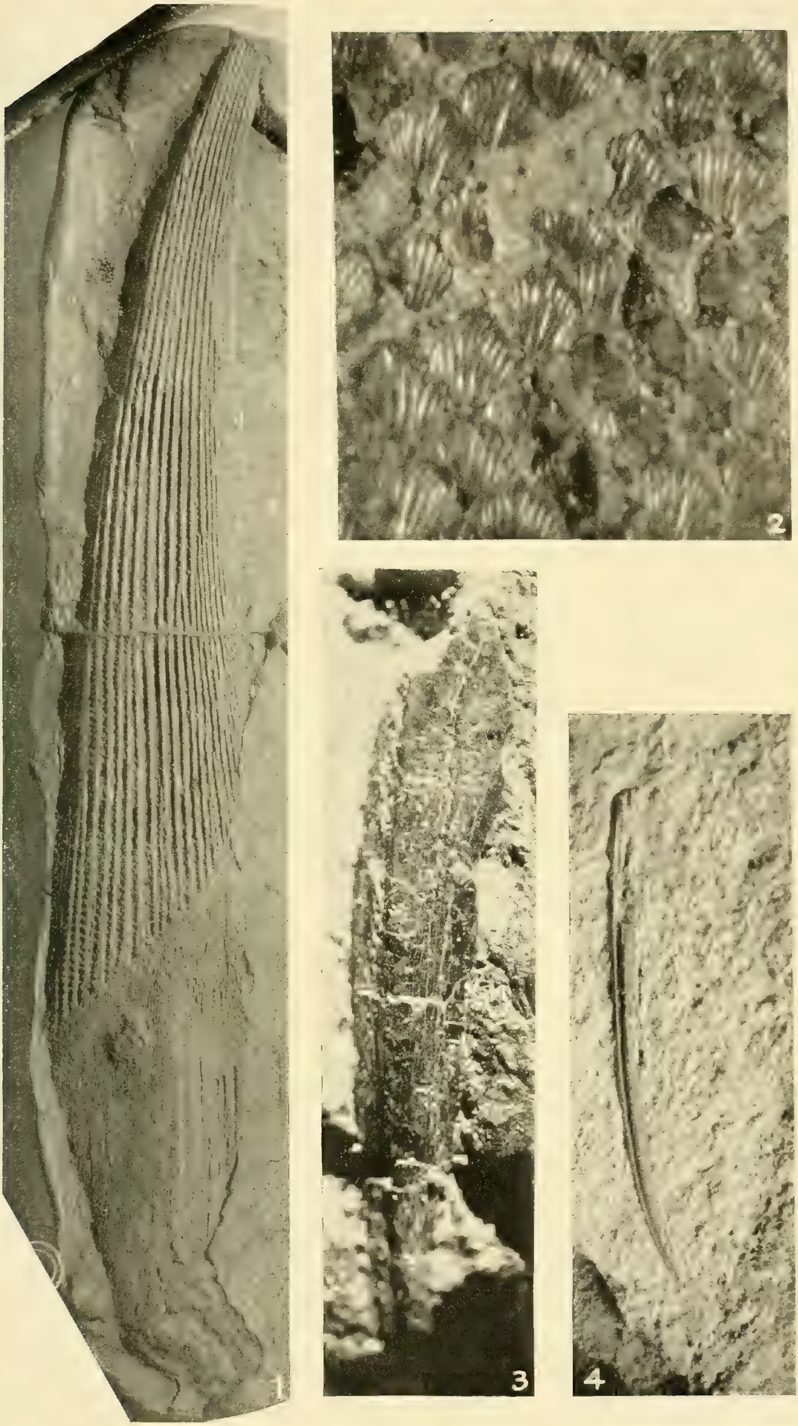
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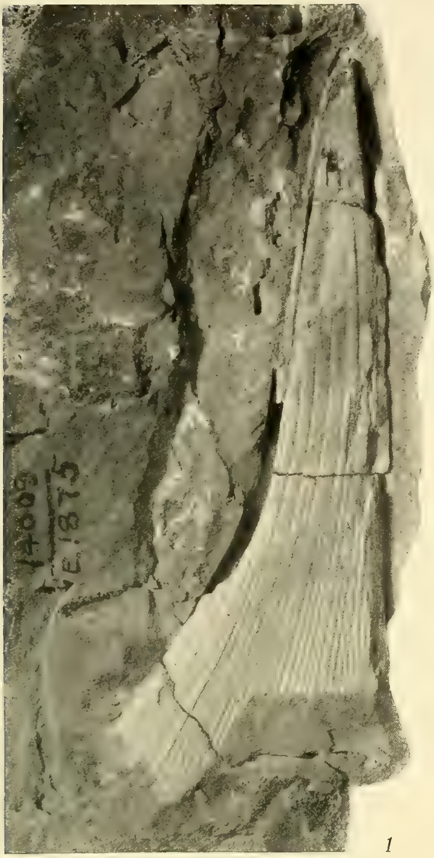
PLATE 52

Fig. 1. *Gamphacanthus uddeni* (Lindahl). Spine in matrix; natural size. E 1875, p. 164.

Fig. 2. *Ctenacanthus wrighti* Newberry. Fragment of a spine showing characteristic ornamentation. $\times 1\frac{1}{3}$. E 1904, p. 161.

Figs 3, 5. *Gyracanthus sarlei*, n. sp. Type, E 2487, p. 142.
3. Proximal half of spine, in matrix; $\frac{4}{5}$ size.
5. Cross-section, $\times$ 5.

Fig. 4. *Gyracanthus* sp. Spine, $\times 1\frac{1}{2}$. E 2489, p. 144.



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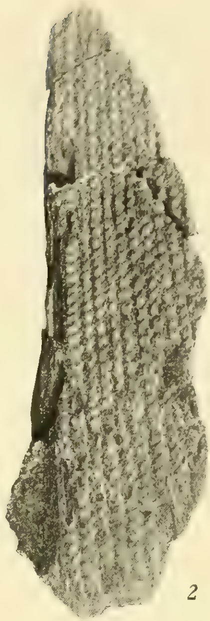
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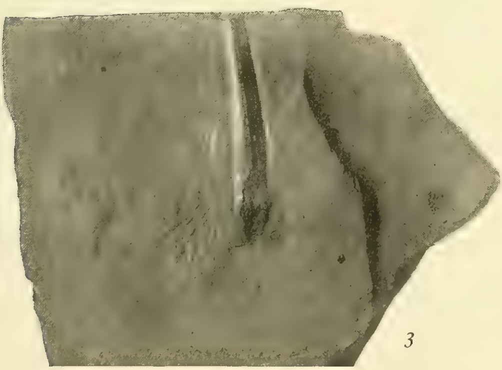
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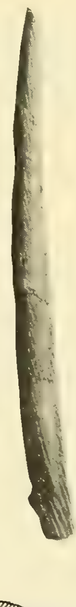
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PLATE 53

Fig. 1. *Machæracanthus major* Newberry. Distal half of spine, in matrix $\times \frac{4}{5}$. E 1849, p. 166.

Fig. 2. *Machæracanthus major* Newberry. Distal half of spine, in matrix. $\times \frac{4}{5}$. E 1848, p. 166.

Fig. 3. *Machæracanthus peracutus* Newberry. Distal half of spine, in matrix. $\times \frac{4}{5}$. E 1850, p. 167.

Fig 4. *Machæracanthus* sp. Distal extremity of spine, in matrix. $\times \frac{4}{5}$. E 2514, p. 168.

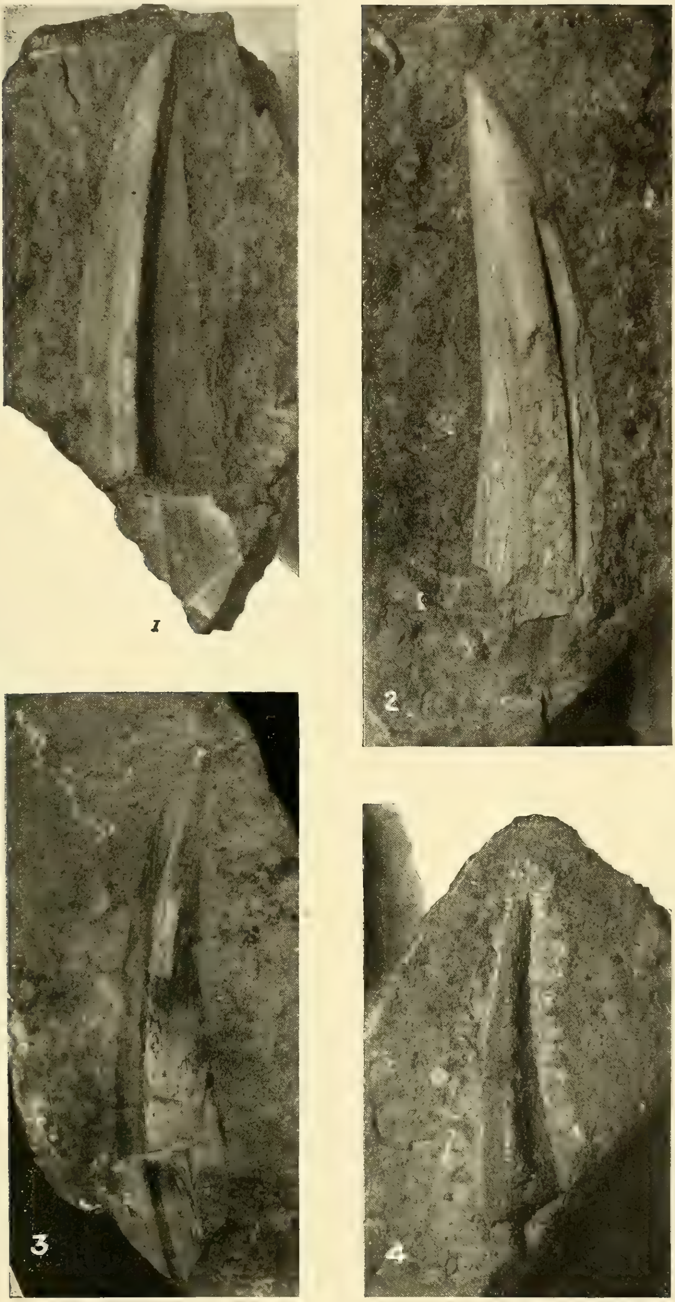
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PLATE 54

Figs. 1, 1a, 2. *Stethacanthus præcursor*, n. sp., p. 169.

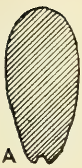
1. Lateral view of spine, based on the two cotypes; natural size.

1a. Cross-section at about one-third from apex; natural size.

2. A nearly complete spine—the more perfect of the two cotypes; natural size. E 1908.

Fig. 3. *Stethacanthus depressus* (St. John and Worthen). Small spine, × 2. E 2516, p. 170. (Original is an impression in sandstone, and the figure is from a wax squeeze of it.)

1



1A

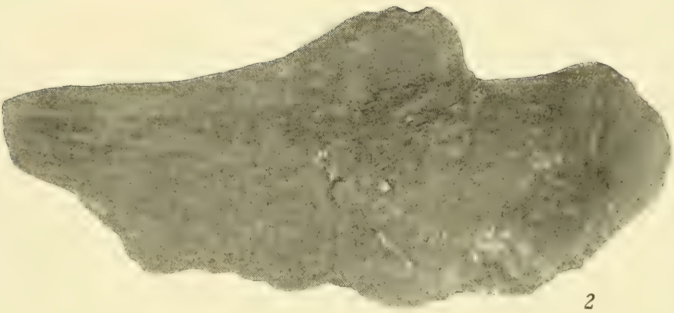


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PLATE 55

(All figures natural size)

Figs. 1, 2. *Synthetodus calvini* Eastman. Dental plate. E 2017, p. 150.
1, inserted face; 2, oral face, showing a large worn boss.

Fig. 3. *Acmoniodus clarkei*, n. g., n. sp. Type. Large dental plate, in oral view; nat. size. It shows an elliptical anterior tritor, and a larger, subtriangular, posterior tritor. (Cf. text-fig. 53.) E 2575, p. 152.

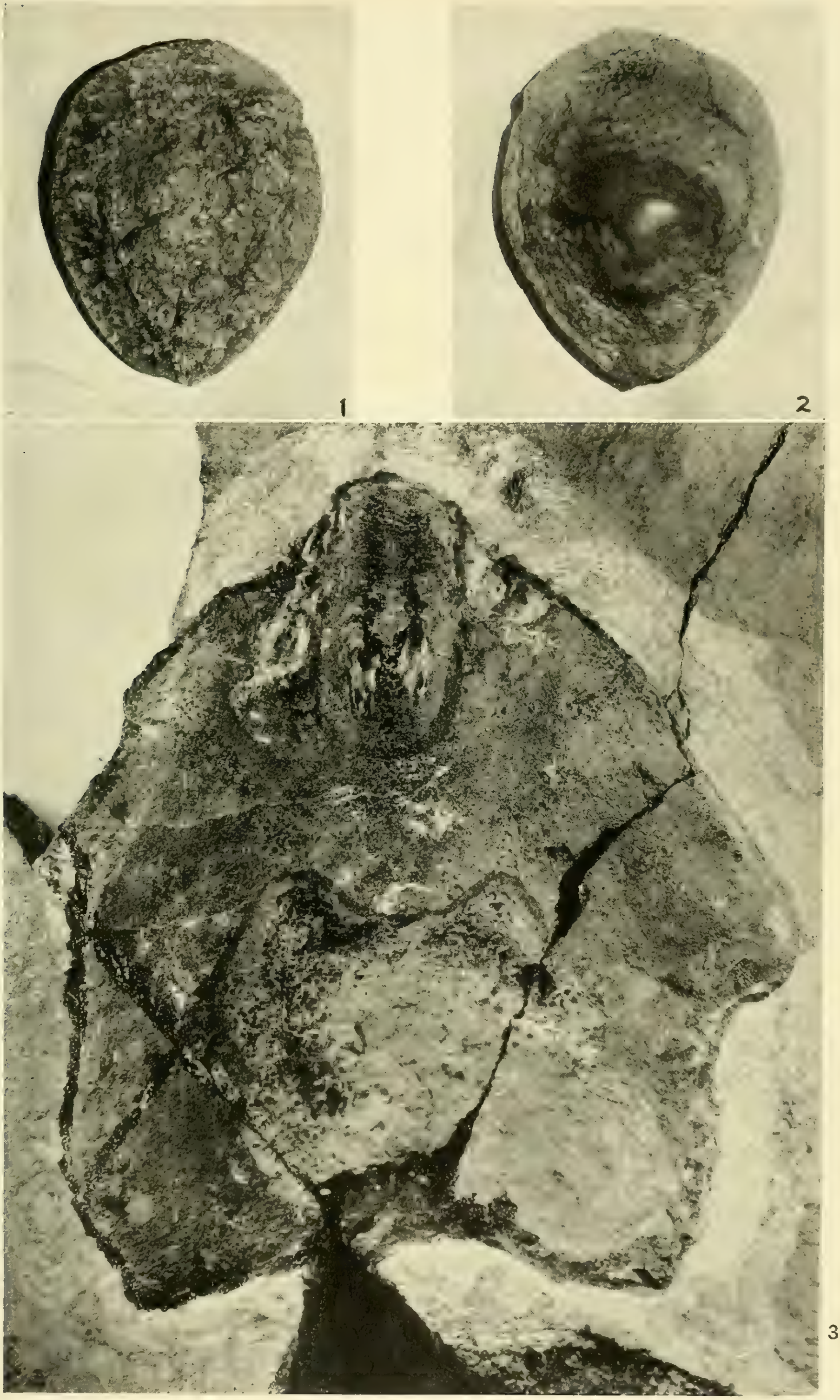
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PLATE 56

Fig. 1. *Dipterus* sp. A small dental plate, in matrix. × 2. E 2015, p. 171.

Figs. 2, 2a. *Dipterus gemmatus*, n. sp. Type. Dental plate, in matrix, E 2517, p. 170. Fig. 2 is × 3; 2a is × 5, to bring out the surface punctæ.

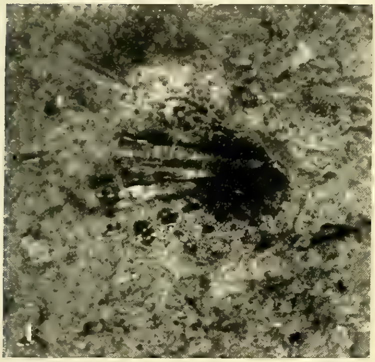

PLATE 57

Figs. 1, 2. *Cheirolepis canadensis* Whiteaves. Enlargement of scales, × about 25.

Both figures from E 2558, p. 181.

Fig. 3. *Scaumenacia curta* (Whiteaves). Impression of posterior portion of upper surface of head, showing sutures and sensory canals. Near the head is seen the dentition. E 2521, p. 172.

Fig. 4. *Scaumenacia curta* (Whiteaves). Dentition shown in preceding figure, ×3.

Figs. 5, 6, 7. Enlargement of shagreen scales found isolated in the Conodont bed. Fig. 6 is the under side of a scale like that in Fig. 5, and shows a flange for overlap.

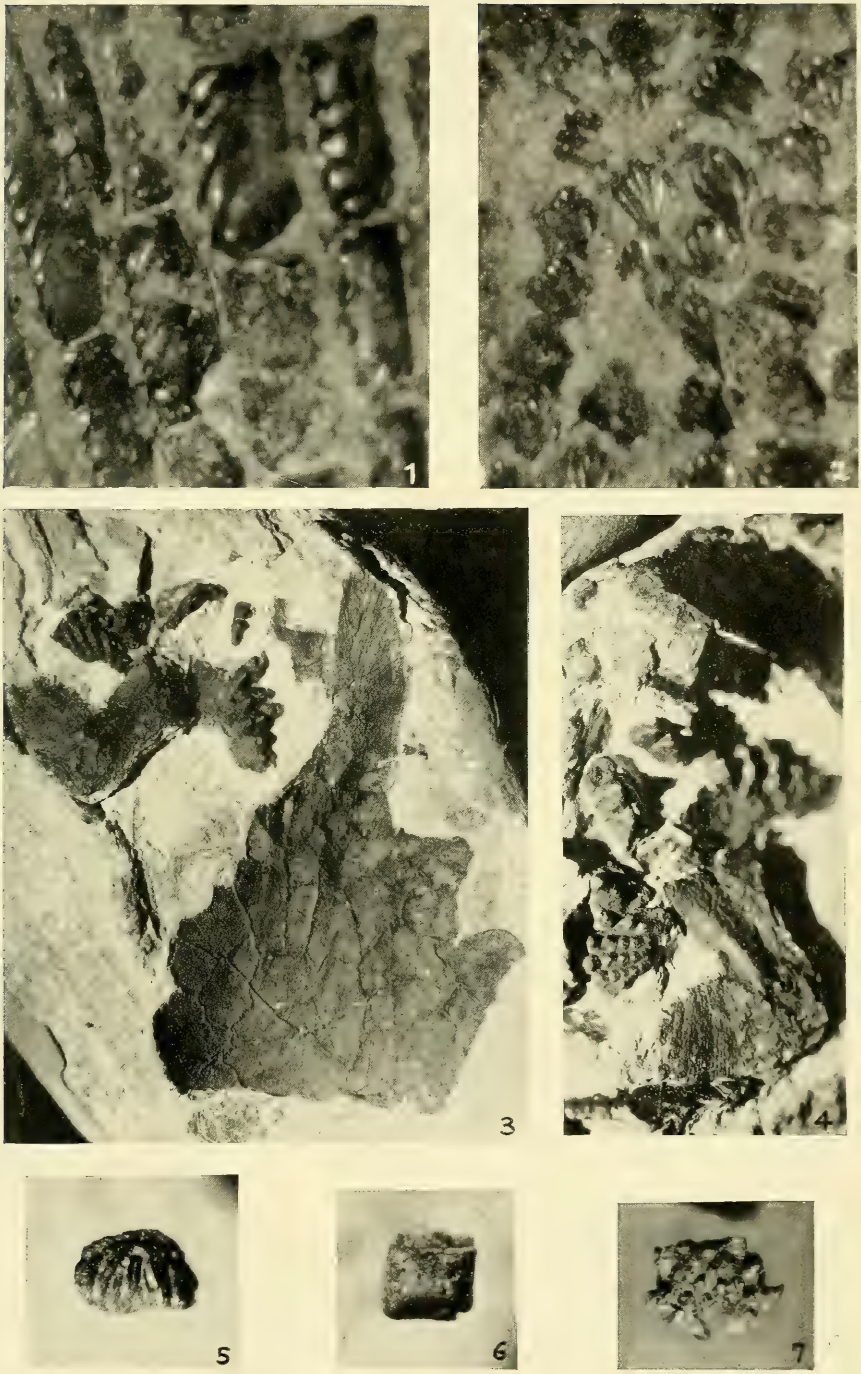
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PLATE 58

Onychodus sigmoides Newberry

Fig. 1. Laniary tooth from mandible, × $\frac{5}{6}$. E 1873, p. 180.

Fig. 2. Series of 6 premandibular teeth, with their supporting symphyseal bone; natural size. E 1871, p. 180.

Fig. 3. Left mandible, lacking anterior extremity; outer view. × $\frac{4}{5}$. E 2556. (Cf. text-fig. 59.) p. 179. *ang*, angular; *art*, articular; *den*, dentary.

3a. Tooth of preceding enlarged 3 times.

3b. Enlargement of surface ornamentation of mandible shown in Figure 3.


1.
2.
3a
3b.
3

PLATE 59

Rhadinichthys devonicus (Clarke)

Imperfect fish on shale, showing outline of body and the caudal fin. Natural size. E 2044, p. 184.

PLATE 60

Rhadinichthys devonicus (Clarke)

Fig. 1. Cleithrum, × 3½. E 2048. (Cf. text-fig. 61 *A*.) h. 184.

Fig. 2. Operculum, × 3. E 2047. (Cf. text-fig. 61 *B*.) p. 184.

Fig. 3. Cranial plates, × 5. E 2045, p. 184.

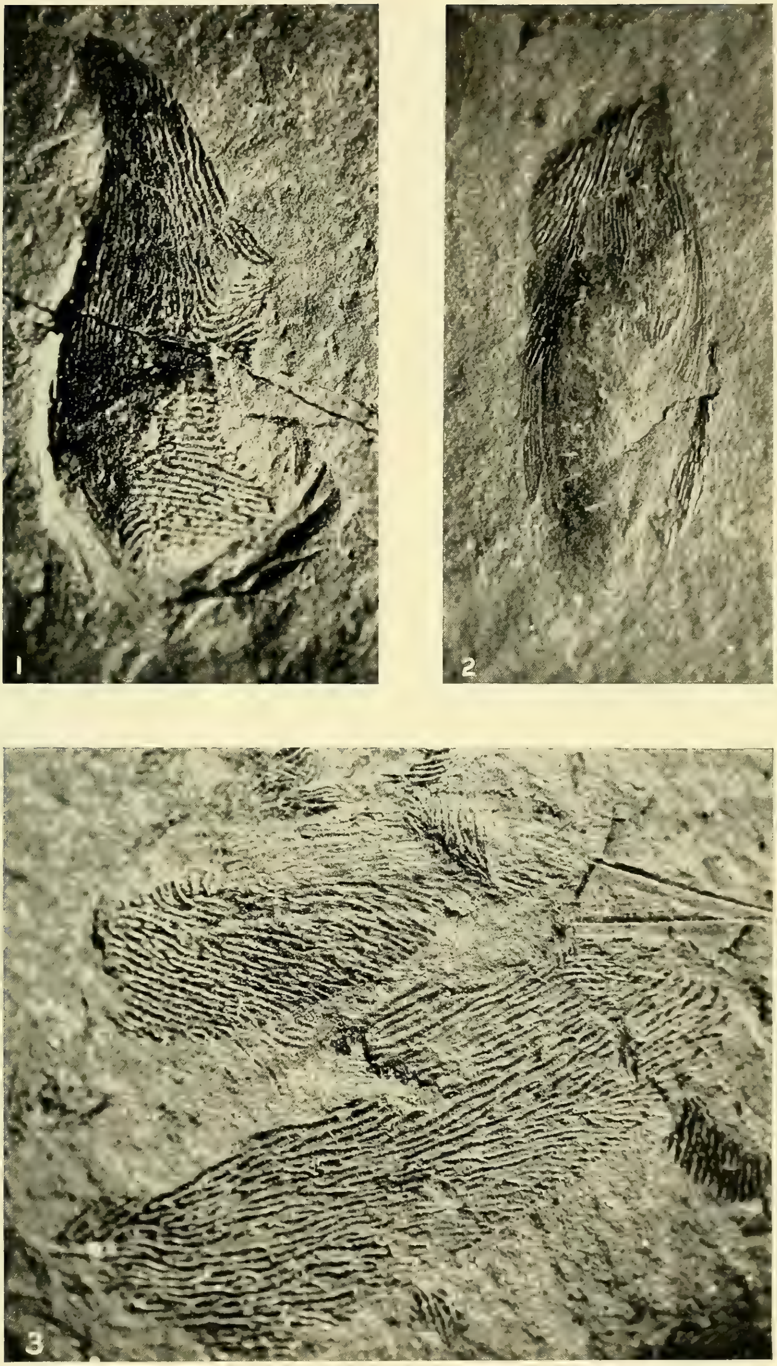
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PLATE 61

Rhadinichthys devonicus (Clarke). × 4

Fig. 1. Right maxilla; outer view. It shows well the surface ornamentation. E 2051, p. 184.

Fig. 2. Right maxilla; outer view. The surface ornamentation is denuded, but the teeth are well shown. (Cf. text-fig. 61 *C*.) E 2067, p. 185.

Fig. 3. Right maxilla, defective posteriorly; outer view. E 2050, p. 185.


2.
3.

PLATE 62

Rhadinichthys devonicus (Clarke)

Fig. 1. Left mandible, denuded of surface ornamentation. × 4. E 2055, p. 184.

Figs. 2, 3. Detached scales, magnified, to show surface ornamentation. E 2061, p. 184.

Fig. 4. Cranial plates and scales, showing characteristic ornamentation of his species. × 5. E 2049, p. 184.

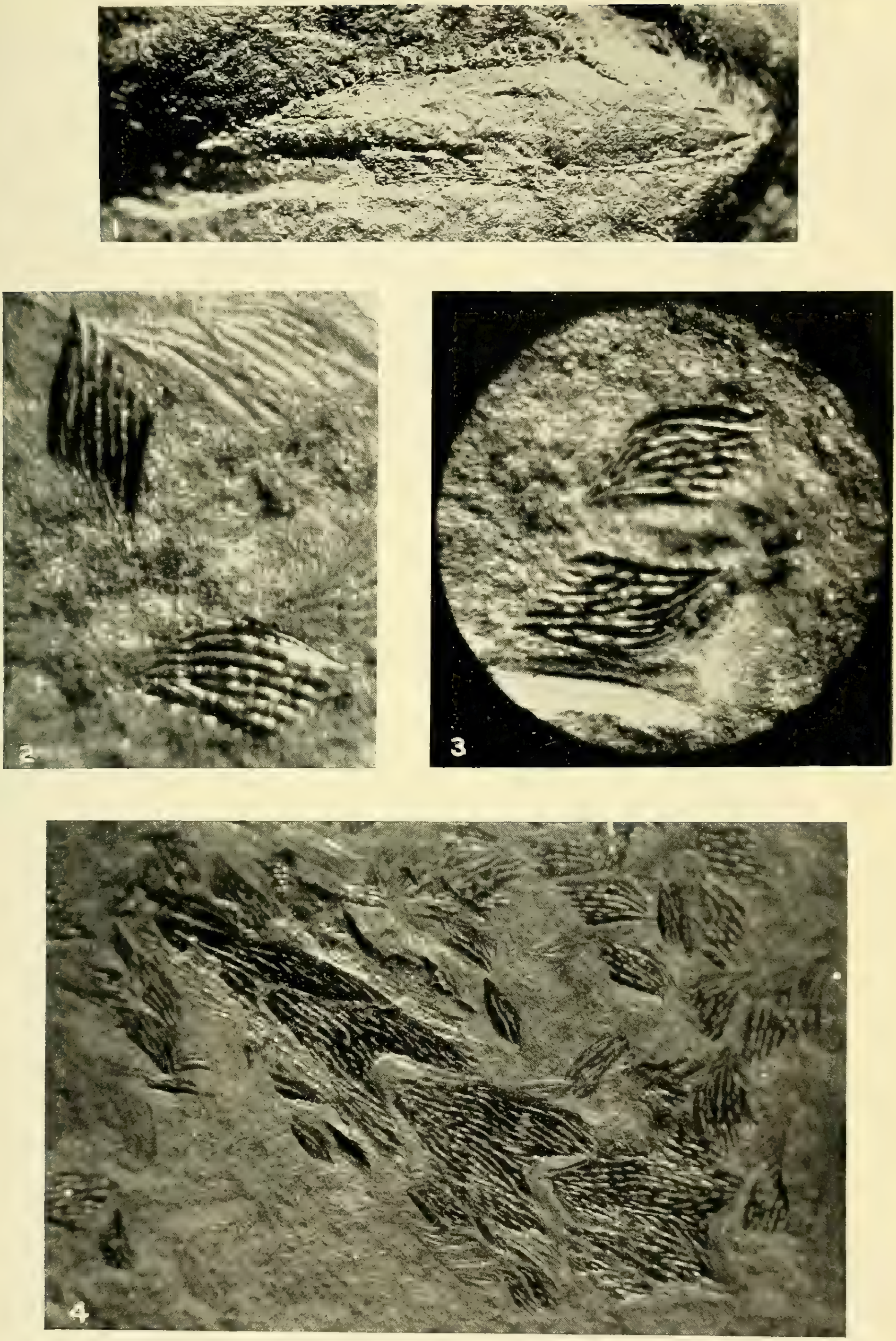
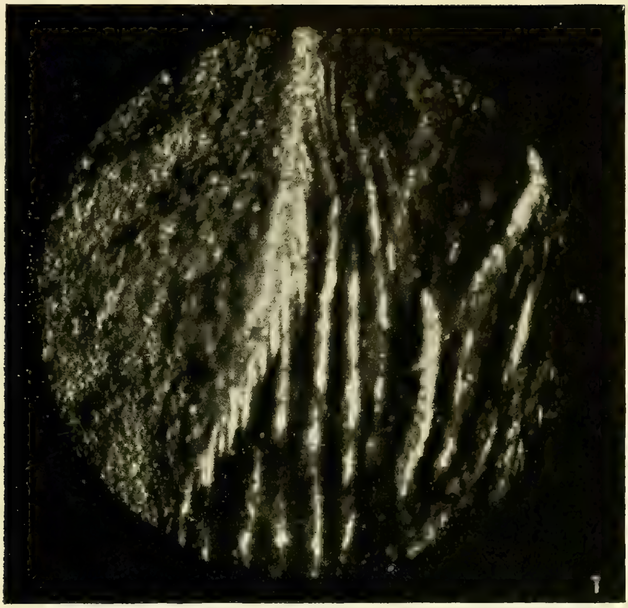


PLATE 63

Figs. 1, 2. *Rhadinichthys devonicus* (Clarke). Fin-rays, highly magnified. Part of same specimen as cranial plates shown in Plate 62, figure 4. E 2049, p. 184.

Fig. 3. *Rhadinichthys antiquus* (Williams). Caudal extremity of fish, showing scales and the fulcra of lower lobe. × 5. E 2065, p. 186.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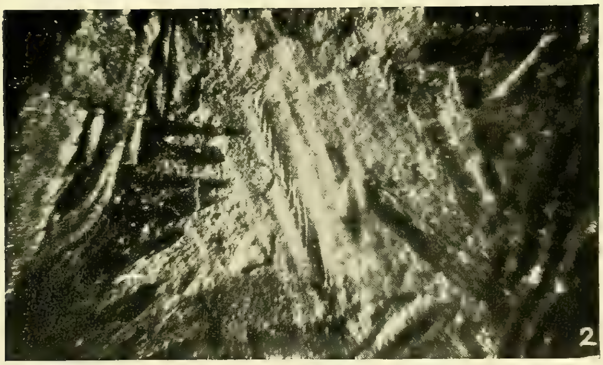
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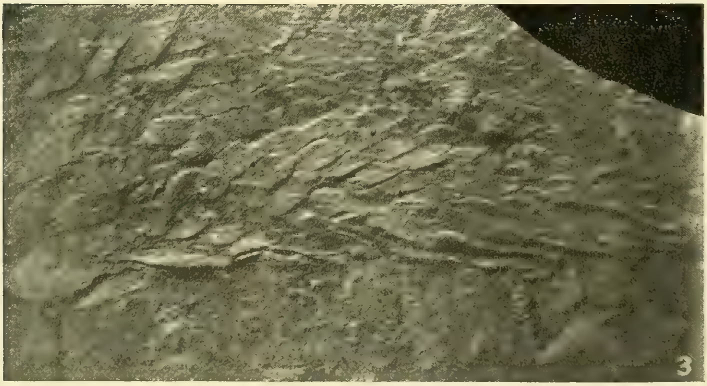
3

PLATE 64

Rhadinichthys antiquus (Williams)

Fig. 1. Left cleithrum, × $2\frac{1}{2}$. E 2068, p. 186.
Fig. 2. Ridge scale, outer view. × 9. E 2074, p. 187.
Fig. 3. Ridge scale, inner view. × 8.
Fig. 4. Ridge scales, inner view. × 8. E 2074, p. 187.
Figs. 5, 6. Detached scales, × 9. E 2074, p. 187.

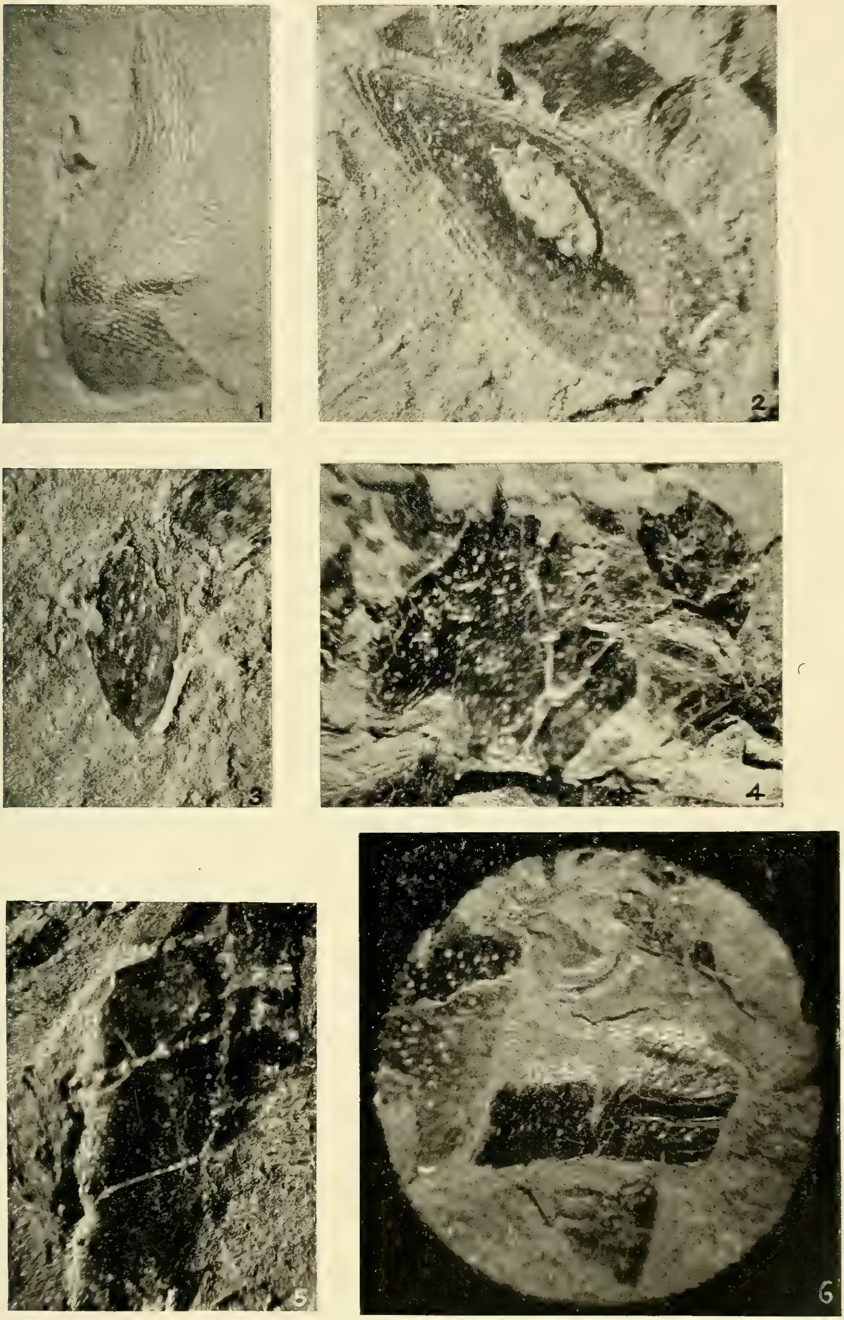
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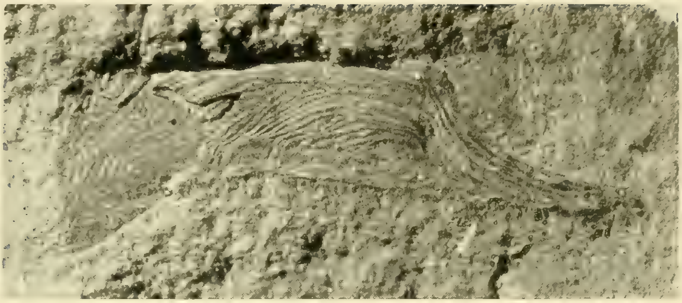
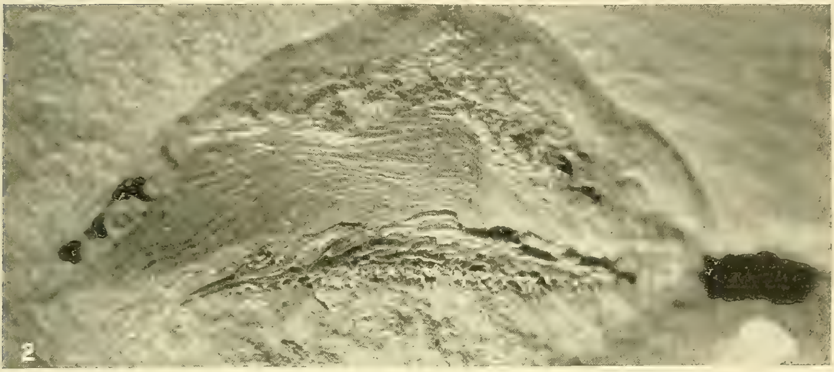
PLATE 65

Fig. 1. *Rhadinichthys devonicus?* (Clarke). Right maxilla, outer view, showing nearly entire outline and the surface ornamentation. × 4. E 2565, p. 185. Cleveland shale; Ohio.

Fig. 2. *Rhadinichthys devonicus* (Clarke). Right maxilla, in outer view; from the Portage shale, near Buffalo, N. Y., for comparison with the preceding from the Cleveland shale. × 4. E 2c66, p. 185.

Fig. 3. *Rhadinichthys devonicus?* (Clarke). Mandibles, separated from each other and both displaying the outer, ornamented surface. × 4. E 2566, p. 185. Cleveland shale; Ohio.




2


3

PLATE 66

Rhadinic'thys elegantulus (Eastman)

Figs. 1, 2. Two enlargements of the same fish. 1, is × 3; 2, is × $2\frac{1}{2}$. E 2092, p. 190.

Fig. 3. Caudal extremity of an imperfect fish. The figure shows well the dorsal and anal fins. × 4. E 2093, p. 190.

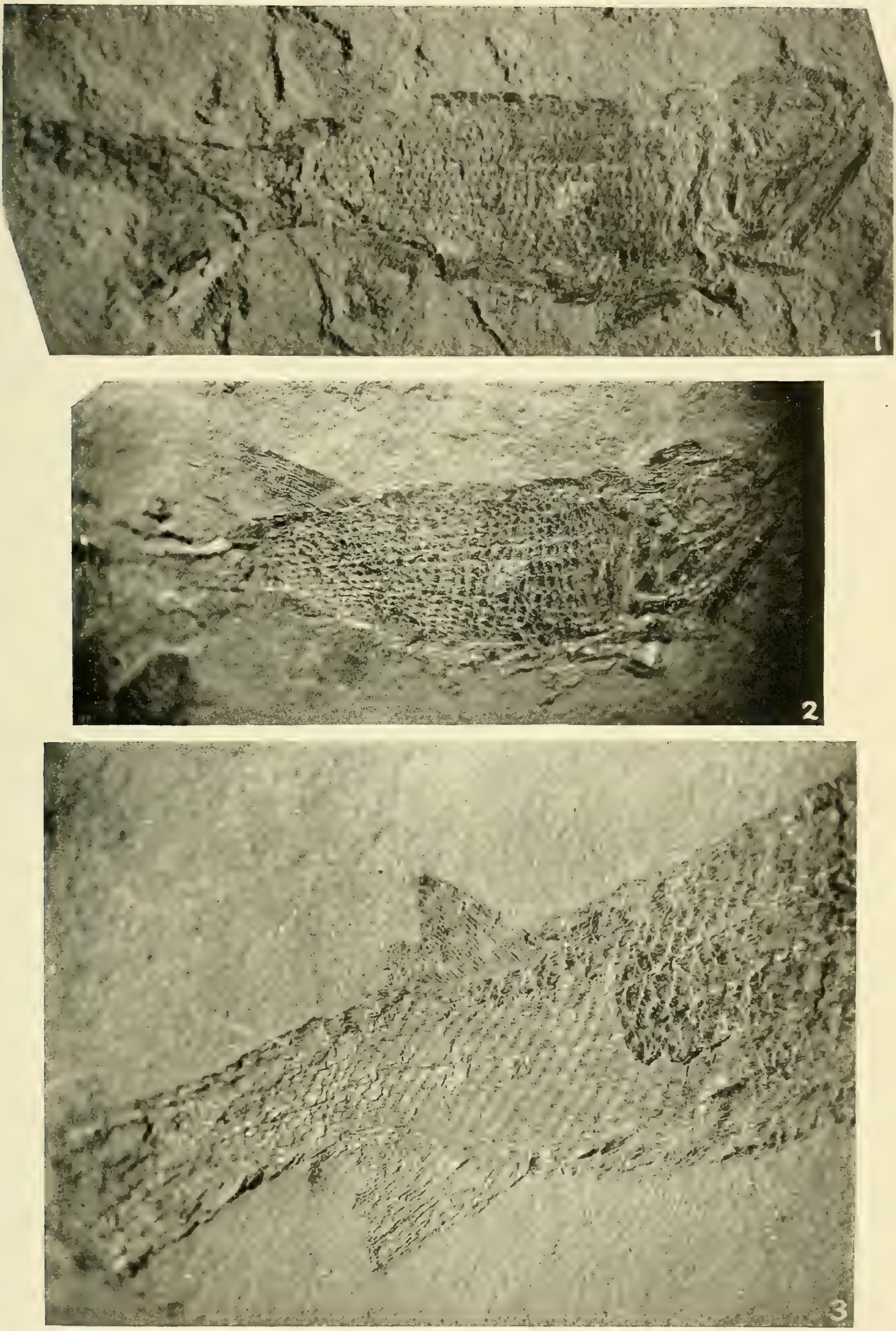

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PLATE 67

Dictyopyge macrura (W. C. Redfield)

A slab of shale containing remains of 10 fishes, one of them (the bottom one in the figure), almost complete. $\times \frac{3}{5}$. E 2126. p. 193. Triassic; Richmond, Va.

PLATE 68

Lepisosteus simplex Leidy. $\times$ about $\frac{1}{5}$. E 2150, p. 196. Green River shales: Wyoming.

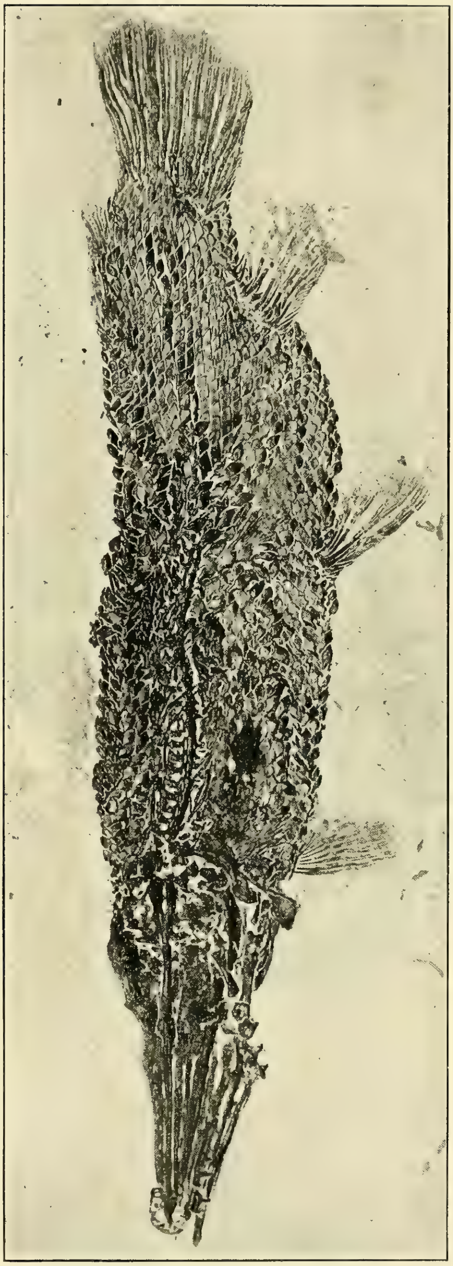


PLATE 69

Fig. 1. *Stenognathus ringuebergi* (Newberry). Slab of shale, 65 by 37 cm., showing the dorsomedian (*DM*), a postero-ventrolateral plate (*V*), and portion of the notochord (*N*) with neural (*n. a.*) and haemal (*h. a.*) arches. $\times \frac{1}{5}$. E 2595, p. 69.

Fig. 2. *Dinichthys tenuidens*, n. sp. Type. Left mandible, in outer view. $\times \frac{4}{5}$ E 2596, p. 55.

I

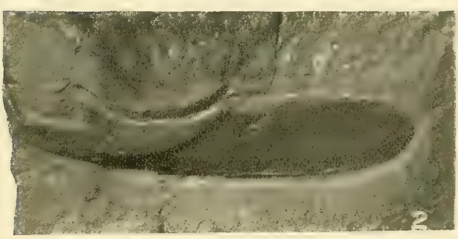
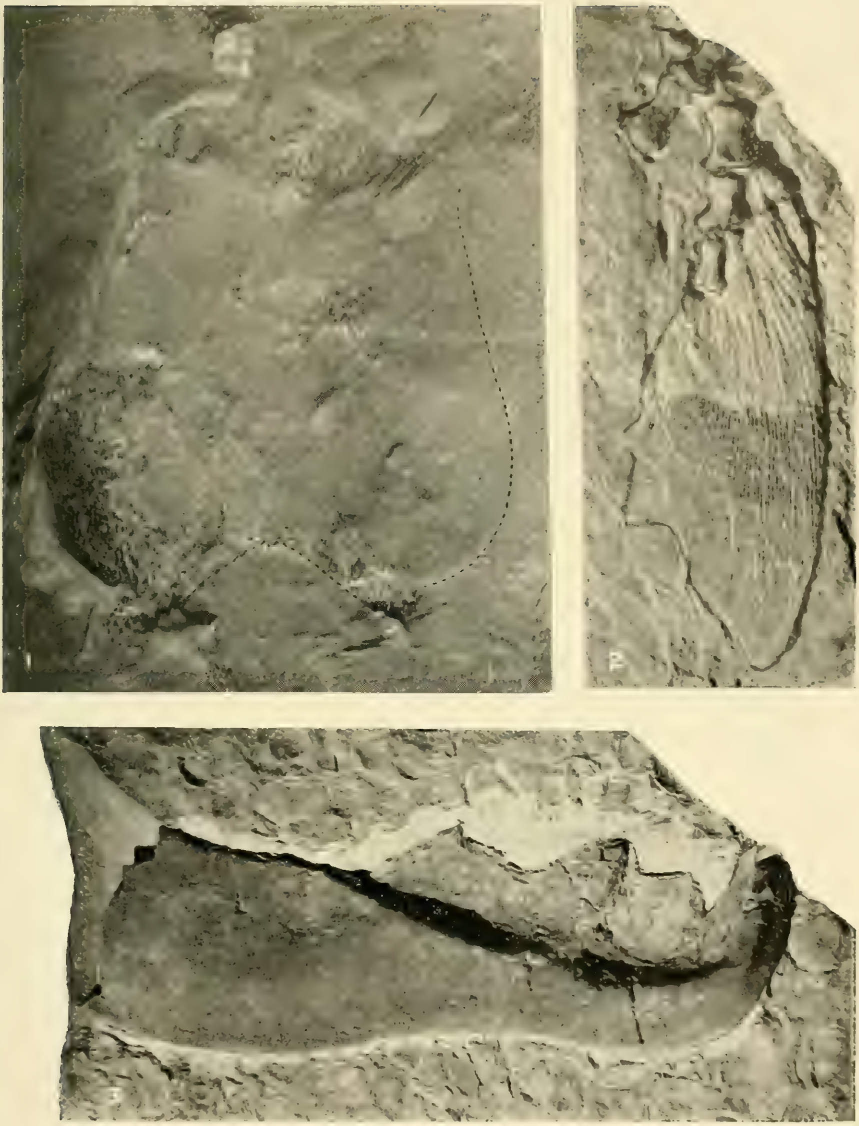


PLATE 70

Fig. 1. *Coccosteus parvulus*, n. sp. Cranial shield, represented chiefly by the impression; the bone is shown only in regions of left orbit, left marginal, and the median occipital. On the left marginal the lateral canal is to be seen. × 1. E 2597, p. 30.

Fig. 2. *Eusthenopteron foordi* Whiteaves. Pectoral fin, × 1. Belongs to specimen, E. 2594, p. 178.

Fig. 3 *Dinichthys* sp. Left mandible, in inner view, × $\frac{1}{3}$. Collected and presented by Mr. E. J. Armstrong, Erie, Pa. E 2598, p. 54.



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Detailed descriptions of species are referred to by **black face** numbers. Illustrations are indicated by an *. Mere incidental references to species are as a rule omitted.

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